European Forum for Studies of Policies for Research and Innovation

Instituto de Políticas y Bienes Públicos

Early Career Researcher Conference (ECRC)

Science dynamics and research systems:
The role of research for meeting societal challenges"

Madrid, 8-9 April 2013

Cooperative Research Centres and Sectoral Systems of Innovation: a typology based on the Spanish case

Inés Andújar

Contact: iandujar@iesa.csic.es

Sandro Giachi

Institute for Advanced Social Studies
Spanish National Research Council (IESA-CSIC), Córdoba, Spain

C/ Albasanz 26-28, 3D
28037 Madrid. SPAIN
http://www.ipp.csic.es

Cooperative Research Centres and Sectoral Systems of Innovation: a typology based on the Spanish case

EU-SPRI Early Career Researcher Conference (ECRC) on "Science dynamics and research systems: The role of research in meeting societal challenges"

Inés Andújar[1] and Sandro Giachi[2]

Contact: iandujar@iesa.csic.es

[1, 2] Institute for Advanced Social Studies
Spanish National Research Council (IESA-CSIC), Córdoba, Spain

Abstract: This paper develops a typology of Cooperative Research Centres (CRCs) in Spain through the sectoral system of innovation (SSI) approach. A CRC is a type of R&D organization that joins different public and private R&D actors and carries out collaborative market-oriented research on areas of industrial relevance (CREST, 2008). From the SSI perspective, CRCs can be thought as a type of interaction among heterogeneous agents ─private companies, universities and research organizations, and government─ structured by formal collaborative R&D arrangements. Based on this approach, we suggest an empirical-based typology of CRCs in Spain that distinguishes four main types of centres: (1) “Small potential innovators”; (2) “Transnational potential innovators”; (3) “Local technological developers” and (4) “Transnational technological developers”. The first two types ─1 and 2─ could have a knowledge base and human resources more academic and scientifically specialised, while the other types ─3 and 4─ would use a more technical knowledge. On the other hand, types 2 and 4 would have a greater proportion of large firm partners and a more open and international demand, while types 1 and 3 would have a greater proportion of small firm partners and a demand more domestic and local. We also evidence some connections between types of CRCs and sectors of economic activity and regions. Our findings are a first step towards a better understanding of CRCs in Spain.

1. Introduction

Synergistic interactions among heterogeneous R&D agents ─for example, universities, research organizations, private companies and government─ are key and valuable connections for the creation, transformation and diffusion of new knowledge and innovation (for example, Kline and Rosemberg, 1986; Von Hippel, 1988; Dosi, 1988; Etzkowitz and Leydersdorff, 2000). In this context, the so-called Cooperative Research Centres (CRCs) arise as promising organizational arrangements for public-private research collaboration. A CRC is a type of R&D organization that joins different public and private R&D actors and carries out collaborative market-oriented research on areas of industrial relevance (CREST, 2008). Studies on CRCs stress the key role of these centres for the strategic use of science and technology, for transferring know-how and new ideas from the Academy to the productive sector and for analysing how to face important organizational challenges due to different expectations and goals of the agents involved (for example, Boardman and Gray, 2010; Feller at al., 2002; Garrett-Jones and Turpin, 2010; Roessner 2000 or Turpin et al. 2005). CRCs appear even more crucial elements within the current economic crisis.

In spite of its recognised importance, CRCs are a recent and unexplored phenomenon in Spain (Fernández-Esquinas and Ramos-Vielba, 2011). There is a lack of understanding of such type of research centres, for example, about their orientation, funding, human resources management or knowledge base. This paper analyses a collected sample of Spanish CRCs and suggests a typology of these centres as a necessary first step towards their understanding. We ground our typology on the notion of Sectoral System of Innovation (SSI). In order to perform the analysis, we use data from a multi-method survey directed to the heads of 163 CRCs in Spain (final sample of 123 CRCs). This survey was conducted in the framework of the "ES-CRCs" research project ─"Emerging Forms of Cross Sector Collaboration between Science and Industry: Cooperative Research Centres in the Spanish R&D System"─ launched in 2010 by IESA-CSIC.

The paper is structured as follows. Section 2 presents the SSI concept and the CRCs from this conceptual approach. Section 3 describes our data, sample and variables. Section 4 presents the results of our empirical analysis and section 5 summarises the main findings of our study and suggests future lines of research.

2. Sectoral Systems of Innovation and Cooperative Research Centres

The SSI concept

As it is widely acknowledged by the literature, innovation follows different sectoral patterns (for example, Nelson and Winter, 1982; Pavitt, 1984; Malerba and Orsenigo, 1999). These contributions have often identified innovation sectors with traditional sectors of economic activity, focusing on specific differences among them. The sectoral system of innovation concept (SSI) departs also from the traditional concept of sector but enlarges it taking into account additional actors, interactions and processes. In doing so, the SSI approach integrates the wide range of findings on innovation reported in the specialised literature and proposes a dynamic view of the innovation sectoral boundaries. A SSI is "a set of new and established products for specific uses and the set of agents carrying out market and non-market interactions for the creation, production and sale of those products" (Malerba, 2002: 248). This concept is grounded in the evolutionary theory. According to this approach, sectoral boundaries are defined by specific features of three building-blocks (Malerba, 2007): (1) the knowledge and technological domain ─knowledge base, learning processes and basic technologies, inputs and demand─; (2) the interactions and networks among agents ─individuals and organizations─ and (3) the institutions ─norms, routines, laws, etc.

According to the SSI approach, each one of these building blocks co-evolves with the others through processes of creation of variety and selection, shaping dynamic sectoral boundaries. The evolutionary theory particularly stresses the interactions among heterogeneous agents ─building block 2─ as a key factor of the innovation process (for example, Loasby, 2001; Potts, 2000). These interactions, according to Malerba (2002, 2007), differ between each sectoral system as a consequence of the features of the knowledge base, the basic technologies, inputs and the characteristics of demand ─ i.e., building block 1. Relating to building block 3, institutions ─understood as a set of rules and routines commonly adopted─ are referred to different levels of aggregation ─supranational, national, regional─ or limited to the boundaries of firms or other organizations. A particular feature of the SSI approach is that it considers and allows studying the co-existence of these local, national and/or global dimensions of a sector (Malerba, 2007).

Cooperative Research Centres through the Sectoral System of Innovation Approach

Many labels have been used to describe public-private initiatives or CRCs ─ competence centres, hybrid centres, boundary organizations or engineering research centres, among others. Despite these multiple "tags", there is an agreement in pointing out the following main features of CRCs (CREST, 2008: 4-5): (i) they are formal autonomous organizations; (ii) their main goal is to carry out collaborative research among private enterprises, research performing organizations and public service organizations and (iii) they conduct market-oriented research typically focused on medium/long term issues and on areas of direct industrial relevance. CRCs pose important issues for current research systems. According to Boardman and Gray (2010), CRCs emerge through new social and organizational forces within current innovation systems ─such as the collectivization of research, the rise of a cooperative paradigm for research policy or the emphasis of open innovation strategies within industry. These centres mobilize the knowledge reservoir of public research organizations and private companies for conducting market-oriented research. This may "encourage firms to undertake more radical kinds of innovation than normal, based on more fundamental understanding of the technologies with which they work" (CREST, 2008: 8) and enables the use of science and technology to address social and economic problems that academic units, government actors and private companies cannot easily face unilaterally (Boardman and Gray, 2010: 452). Within current research systems, CRCs appear as promising creators and diffusers of new knowledge and innovation.

From the SSI perspective, CRCs can be thought as a type of interaction among heterogeneous agents ─private companies, universities and research organizations, and government─ structured by formal collaborative R&D arrangements:

- In relation to company members, literature finds different goals and profiles of the firms involved in a CRC. For example, Santoro and Chakrabarti (2001) find out that large firms participate in CRCs in order to carry out long-time research, whereas SMEs search to solve very specific needs in the short term. Tornatzfy et al. (2002) also find that the main goal of high-tech companies is the recruitment of high qualified staff, whereas low-tech firms search to access to the capabilities and facilities of high quality that CRCs provide. According to various studies (for example, Roessner, 2000; Adams et al., 2001 and Gray et al., 2001), firms that participate in CRCs specially obtain "collaborative benefits": access to new ideas and know-how, faculty consulting, publications in co-authorship with university scientists and recruitment of graduated students. However, the "technical results" ─new products and processes─ are less frequent.

- Regarding universities and research centres, Cohen et al. (1994) report for the case of USA that universities usually get involved in CRCs because of the funding that they offer. In return, the research they conduct is more applied and the diffusion of their findings more restricted. For the Australian case, Turpin and Garret- Jones (2010) find that for researchers that participate in CRCs, one of the most valued aspects of their CRC membership is the extension of their research networks and the access to new research users. These authors also evidence that researchers involved in CRCs usually still work at the University.

- Relating to Public Administrations, they actively promote CRCs as a way to foster innovation and change. In some countries, governments have promoted CRCs through specific R&D national plans. It is the case of United States, Australia, Canada, Austria, Norway, Sweden or Ireland (for example, Roessner, 2000; Gray et al. 2001; Gray, 2011; Atkinson et al. 2001; Howard Partners, 2003; Arnold et al., 2004). In other cases like in Spain, Public Administrations have promoted CRCs through different policy initiatives developed at the regional, national and European levels and emerged mainly since 2000s. The Spanish regional administrations have been an especially active player in this sense (Cruz-Castro and Sanz-Menendez, 2007). In some regions like the Basque Country or Madrid, public regional initiatives have recently promoted networks of new R&D centres for public-private cooperation created from scratch. These CRCs are often private foundations with a strong presence of the public sector and the University. Examples of this type are the BERC and the CRC programs in the Basque Country,[1] and the IMDEA Network in Madrid.[2] In other regions, like Galicia, Catalonia or the Region of Valencia CRCs have mainly been based on pre-existing Technological Centres or previous industrial research associations closer to industrial needs and supported by local SMEs and governments.

As far as we know, the existing literature on CRCs does not apply the SSI approach, although there is evidence of sectoral differences in relation to these centres. Hayton et al. (2010), for example, evidence for the case of USA that firms in more competitive industries and with higher technological opportunity are more likely to join CRCs. They also find that firms operating in weaker patent protected sectors ─like electronic or mechanical industries─ are more likely to join CRCs than firms operating in sectors with a more effective patent protection ─like biotechnology, pharmaceutical or chemical industries. Given the sectoral orientation of CRCs and their potential innovator role, the SSI approach could be suitable for the understanding of CRCs.

For the Spanish case, we find the SSI approach particularly helpful. The different public CRCs initiatives have given rise to a wide variety of organizational and legal structures in Spain (Fernández-Esquinas and Ramos-Vielba, 2011), making difficult their systematic study. Besides, many Spanish CRC experiences are recent and unexplored. In consequence, a necessary first step towards the understanding of CRCs in Spain is to develop a typology of such centres. The SSI approach provides us with a conceptual framework to undertake this task. In particular, based on the SSI concept, we expect that the Spanish CRCs will vary according to their knowledge base, their basic technologies, inputs and demand characteristics. We also expect to find some connections between specific types of CRCs and sectors of economic activity. Besides, given the important role that regional initiatives have had in promoting CRCs in Spain, we also expect to find linkages between specific types of CRCs and regions.

In particular, we stress the focus that the SSI notion makes on interactive and heterogeneous actors. Within the SSI perspective, the concept of "linkage" is not limited to the exchange-competition-command patterns but it refers to a diversified set of relationships among R&D and innovation agents, for example the collaborative ones. Linkages could also refer to the connections existing between products and organizational structures (Malerba, 2002). Our approach is also justified by the flexibility that the SSI approach allows in the choice of the level and the unit of analysis. Within this approach, there is an increasing interest in studying formal R&D cooperative agreements and hybrid organizations, emphasizing the role of university-industry relationships as a source of innovation and change. The SSI approach highlights that the

[1] http://www.innobasque.com
[2] http://www.imdea.org/

structure of such organizations differ across sectoral systems, depending on the characteristics of their building blocks components (Malerba, 2007).

3. Methodology

Data and sample

We use data from a multi-method survey directed to the heads of CRCs in Spain (population of 163 CRCs and final sample of 123 CRCs). This survey was conducted in the framework of the "ES-CRCs" research project ─"Emerging Forms of Cross Sector Collaboration between Science and Industry: Cooperative Research Centres in the Spanish R&D System"─ launched in 2010 by IESA-CSIC. Based on Boardman and Gray (2010), we define CRCs as centres that: (1) have a formal structure and have a separate legal entity; (2) conduct R&D activities and (3) have at least one public and one private actor among their partners. The survey includes a wide range of questions about the main activities, resources, organizational issues and results of CRCs.[3]

The response rate was 75.46% (123 centres) of the whole population. The rate of full responses to the questionnaire was 60.12% (98 centres). Response rates are similar across regions (Table 1-A in the Annex): all differences are lower than 1-2%.

Operationalization of the SSI approach and selection of variables

Given the wide scope of the SSI concept, the studies that apply this approach usually focus on some specific features and factors of the building blocks. For example, studies like Adams et al., (2013); Faber and Hoppe (2013); Köhler et al., (2012); Oltra and Saint-Jean (2009) or Chaminade and Edquist (2005) have operationalized the SSI approach in a reductive way, focusing on some specific elements of the building blocks according to their particular research interests and questions. Similarly, for the application of the SSI approach to our study of CRCs, and based on data availability, we consider a reduced set of variables *proxies* to their knowledge base, inputs and demand ─building block 2─ and to some attributes of the heterogeneous CRCs partners and relationships ─building block 1.

The list of our variables is the following (Table 1):

[3] Box 1-A in the Annex details the sampling process and design.

- In relation to the *Attributes*, we consider the proportional distribution that each type of partner ─universities and research centres, firms and Public Administrations─ has in the ownership of the centre (A2) and the number and size of the firm partners (A8). Specifically, we use: private firms share in the CRC property *(% Industrial property*); public organizations share in the CRC property (*% Public property*); proportion of firms involved in the CRC with less than 50 employees, over the total number of firm-partners (*% Small firms*) and proportion of firms involved in the CRC with more than 250 employees over the total number of firm-partners (*% Large firms*).

- Regarding *inputs*, we consider the proportional distribution of two different sources over the total budget of the centre (B3) and the proportional number of their high qualify human resources (B5). In particular, we use: the proportion of CRC funding coming from direct public aids on the total budget (*% Public subsidies on total budget*); the proportion of CRC funding coming from contracts and services to firms on the total budget (*% Market incomes on total budget*)[4]; the proportion of researchers who attain a PhD over the total CRC's employees (*% researchers with a PhD)* and the proportion of pre-doctoral researchers over the total CRC's employees (*% PhD students*). We assume that CRCs with higher proportion of this type of workers will have a greater academic character, given the greater proximity that researchers and PhD students can have to University.[5]

- *Types of knowledge* are proxied by the level of importance of the basic research in the CRC (*Relevance of basic research*) and by the level of importance of the technical services provision in the CRC (*Relevance of technological services).* Variables referring to type of knowledge (C3) are measured using a five-point scale, ranging from 1 ("Activity is absolutely no important") to 5 ("Activity is very important"). Through these two variables we want to differentiate between centres that use mainly academic or applied scientific knowledge.

- As proxies to *demand*, we use the level of importance of orienting the CRC's activities to the benefits of their own partners (*Relevance of economic benefits for CRC partners*) and the level of importance of orienting the CRC's activities to the benefits of their users and/or customers (*Relevance of economic benefits for customers and users*). Variables referring to demand (C4) are measured using a five-point scale, ranging from 1 ("Activity is absolutely no important") to 5 ("Activity is very important"). Variables referring to demand (C4) are measured using a five-point scale, ranging from 1 ("Activity is absolutely no

[4] Other important source of funding (Competitive Public Calls) was excluded during the analysis as it did not show any correlation with the other variables of the model.

[5] We decided to include both the number of researchers who attain a PhD and of PhD students in order to take into account the orientation of research centres in both R&D and educational and training activities. In particular, some authors consider PhD students as a very important dimension for the evaluation of CRCs and other scientific activities (for example, Bozeman et al., 1999 and Boardman and Gray, 2010).

important") to 5 ("Activtiy is very important"). Through these two variables we want to differentiate between centres more oriented to internal or external benefits.

- Finally, we control by sector and region. "Sector of economic activity" considers six categories ─Agriculture; High-Tech, Medium-Tech and Low-Tech Industry; Services; Others: Energy, Water and Construction─ and "Region" considers the Spanish Autonomous Community in which CRCs are located.[6]

Using these variables, we expect to be able to group CRCs and to build a typology of the Spanish CRCs.

Table 1: Variables used in the analysis

	Name	**Description**
Attributes of heterogeneous agents and connections	% Industrial property	% of the private firms in the CRC's property (A2.12)
	% Public property	% of the public organizations in the CRC's property (A2.34)
	% Small firms	% of micro and small firms participating in the CRC (over the total number of firm-partners involved) (A8.12)
	% Large firms	% of big firms participating in the CRC (over the total number of firm-partners involved) (A8.4)
Indicators on the knowledge base, inputs and demand of CRCs	% Public subsidies on total budget	% of the CRC's funding coming from direct public aids (B3.1)
	% Market incomes on total budget	% of the CRC's funding coming from contracts and services to firms (B3.4)
	% researchers with a PhD	% of post-doctoral researchers (over the total CRC's employees) (B5.1)
	% PhD students	% of pre-doctoral researchers (over the total CRC's employees) (B5.5)
	Relevance of basic research	Level of importance of the basic research in the CRC (C3.1)
	Relevance of technological services	Level of importance of the technical services provision in the CRC (C3.4)
	Relevance of economic benefits for CRC partners	Level of importance of orienting the CRC's activities to the benefits of their own partners (C4.2.)
	Relevance of economic benefits for customers and users	Level of importance of orienting the CRC's activities to the benefits of their users and/or customers (C4.3)
Control variables	Sector	Agriculture; High-Tech, Medium-Tech and Low-Tech Industry; Services; Others (Energy, Water and Construction)
	Region	Spanish Autonomous Community

[6] No data for the Autonomous Provinces of Ceuta y Melilla

4. Results

Empirical findings

Table 2 shows the summary statistics. Industrial partners show the highest share of the property of the centres, and small firms are more frequent than the large ones, although these differences are very small. Market incomes are higher than public subsidies in the budget of the centres, and the percentage of PhD researchers and students is not high. Finally, technological services and benefits for customers and users are considered as quite relevant activities for CRCs, in comparison with basic research and benefits for partners respectively.[7]

Table 2: Summary statistics

Variable (N of list = 90)	N	Min	Max	Mean	S.E.	Asymmetry	Kurtosis
% Industrial property	123	.00	100.00	54.82	33.14	-.36	-1.09
% Public property	123	.00	100.00	41.23	32.70	.49	-.94
% Small firms	107	.00	100.00	41.07	39.09	.26	-1.56
% Large firms	107	.00	100.00	38.81	40.00	.53	-1.37
% Public subsidies on total budget	107	0	100	24.06	27.53	1.07	.13
% Market incomes on total budget	107	0	95	31.02	25.65	.48	-.76
% researchers with a PhD	101	.00	83.33	21.68	21.52	1.00	.21
% PhD students	101	.00	31.75	4.85	7.63	1.67	2.22
Relevance of basic research	104	1	5	2.70	1.57	.32	-1.43
Relevance of technological services	105	1	5	3.90	1.23	-.92	-.09
Relevance of economic benefits for CRC partners	103	1	5	2.81	1.54	.21	-1.45
Relevance of economic benefits for customers and users	103	1	5	3.75	1.28	-.79	-.40

Source: Own elaboration based on ES-CRCs Project data.

In order to build an empirical-based typology of CRCs in Spain, we conduct a factorial model with our variables.[8] Using only non-missing values for all the included variables, the size of our sample was reduced to 90 CRCs (73.2% of the total sample and 55.2% of the whole population).

Table 3 shows the factor loadings for the rotated factorial model[9] pre-fixing two factors to be extracted,[10] and Graph 1 shows the distribution of our variables in the factorial

[7] We observe that almost all show a quite normal distribution, being the proportion of PhD students over the total personnel the main exception, although its distribution is not very asymmetrical. However, to facilitate the application of a factorial model (see below), we decided to standardize all variables (normal Z, ranging from 0 to 1).

[8] Previously to the factorial model, we applied a correlation and principal component (PC) analyses to control the relationships and the underlying structural dimensions existing among our variables. Results of these analyses are presented afterwards.

[9] We decided to rotate the axes because in the first model we observed that two variables (percentage of large and small firms) were highly correlated with both the first and the second factor, in an inverse way. We tried first to apply an orthogonal rotation (VARIMAX procedure), but this change did not eliminate

space (for rotated axes). As it can be observed, almost all the variables are important for building the final factors. Besides, although we cannot interpret the axes in the exact way they appear in the graph because they are not orthogonal but oblique, we observe however that the main factor is formed by:

- Structure of property (A2)
- Composition of budget (B3)
- Qualification of personnel (B5)
- Research orientation (C3) and
- Objectives of the centre (C4).

In particular, the first factor (horizontal axis) is positively related with proportion of public property (A2_34), proportion of subsidies (B3_1), proportion of researchers with a PhD (B5_1), proportion of PhD students (B5_5) and relevance of basic research (C3_1). Instead, industrial property, market incomes, technological services and economic benefits are negatively related with factor 1. On the other hand, factor 2 is clearly formed by the size of firm partners, being positively related with the proportion of small firms (A8_12). We observe also that the relation between the axes is not fairly orthogonal, independently of the oblique rotation.

Table 3: Factor Loadings (rotated model)

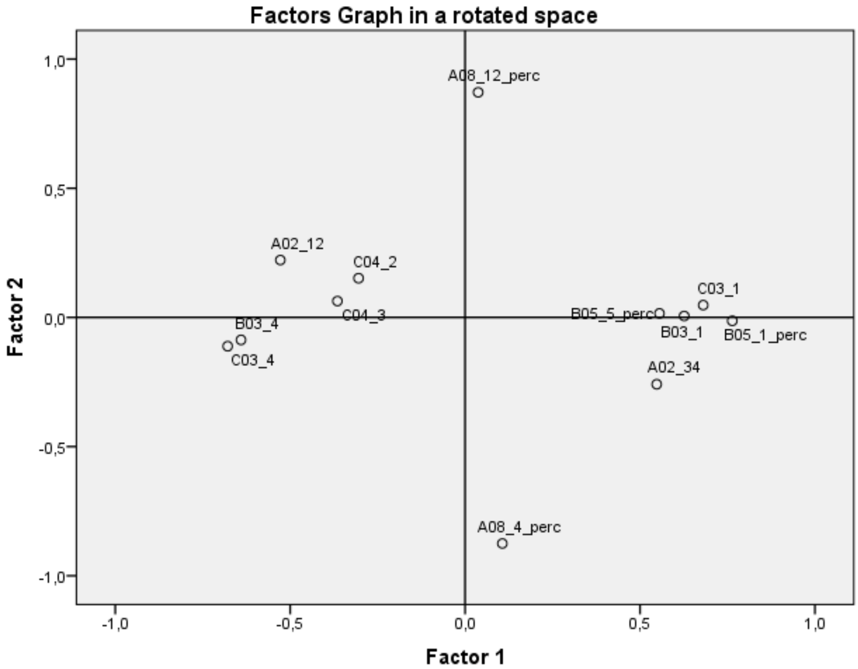
Variable	Factor of rotated model	
	1	2
% Industrial property	-.528	.222
% Public property	.548	-.259
% Small firms	.037	.871
% Large firms	.106	-.875
% Public subsidies on total budget	.626	.006
% Market incomes on total budget	-.641	-.087
% researchers with a PhD	.764	-.013
% PhD students	.556	.015
Relevance of basic research	.681	.048
Relevance of technological services	-.679	-.111
Relevance of economic benefits for CRC partners	-.304	.152
Relevance of economic benefits for customers and users	-.365	.063

Source: Own elaboration based on ES-CRCs Project data.

the problem. Then, we tried with an oblique rotation (OBLIMIN procedure). The model obtained with such procedure was judged as satisfactory, as we achieved to group the explained variance by the percentage of small and large firms in the second factor. Besides, with this last model we achieved a stronger concentration into the first factor, the following variables: Composition of budget, Qualification of the personnel, and Relevance of different research activities. However, as the axes of this model are not perpendicular, we have to be quite careful in explaining results.

[10] This choice derives from the previous PC analysis, as we discuss below.

Graph 1: Factors Graph (rotated model)



Source: Own elaboration based on ES-CRCs Project data.

Table 4 and Graph 2 show the proportion of variance explained by the factors. We used a principal axes factorization algorithm, pre-fixing the number of factors to be extracted (two). The first factor explains 35.5% of the common variance; the second, 8.9% and together, 44.4%. There is a minor increase of explanation of variance from the second to the third factor, supporting our choice to select only the first two dimensions. Besides, the fitting control shows that there is a good adaptation of our data to the model ─ the determinant of the correlation matrix is near to 0, the KMO Index is superior to 0.5 and the Bartlett's Chi-Squared is significantly different to 0 (Table 4).

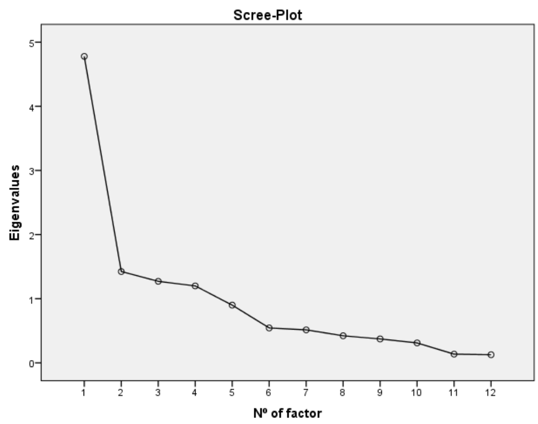
Table 4: Factor Analysis Explained Variance

Factor	Eigenvalues			Squared sum of saturations		
	% of variance	% cumulate	% of variance	% cumulate	% of variance	% cumulate
1	4.778	39.821	39.821	4.265	35.540	35.540
2	1.424	11.866	51.686	1.067	8.889	44.429
3	1.271	10.592	62.279			
4	1.200	9.996	72.275			
5	.900	7.501	79.775			
6	.544	4.536	84.311			
7	.515	4.288	88.600			
8	.422	3.517	92.117			
9	.372	3.104	95.221			
10	.311	2.593	97.813			
11	.136	1.132	98.945			
12	.127	1.055	100.000			
Fitting Index						**Value**
Determinant of the correlation matrix						0.02

Kaiser-Meyer-Olkin.(KMO) Index		.760
Bartlett test of sphericity	Chi-squared	515.064
	DF	66
	Sig.	.000

Source: Own elaboration based on ES-CRCs Project data.

Graph 2: Factor Analysis Scree-Plot



Source: Own elaboration based on ES-CRCs Project data.

The high correlations among variables justify the application of the factorial model justify the application of the factorial model. The correlations matrix (Table 2-A) shows many significant correlations, some of them negative. In particular, the structure of property, the budget composition and the workforce qualification are the variables showing the higher number and coefficients of correlation, while the level of importance of orienting CRC's activities to the benefits of their own partners, other customers or users the lowers.

Also, the results of a previous principal component analysis (PCA) justify our decision (Tables 3-A and 4-A, and Graph 1-A in the Annex). We applied this analysis in order to synthetize all the variance existing in our dataset, identify the most relevant factors and control the extent of the covariance explained by our variables. Although there are four components with an eigenvalue higher than 1, we decided to consider only two factors in the analysis because:

- The first two components explain the 51.86% of the total covariance (Table 3-A)
- The third and fourth factors are built by variables that participate mainly in the first two components (Table 4-A)
- The first two components have a good explanatory capacity, in comparison with the others (Graph 1-A)
- Two components facilitate to a great extent the theoretical interpretation of our model

These previous controls strengthen our decision to apply a factorial model to our variables, with two pre-fixed factors.

A suggested typology of CRCs in Spain

The results of the factor analysis allow us to develop an empirical-based typology of CRCs in Spain. Using the factor loadings of the rotated model as guidelines (Table 4), the interpretation of the factor loadings allows us to identify: On one hand, Factor 1 could be called “Public-Academic vs. Private-Market Orientation of CRCs”. It would summarize the different share of the public, academic, private and industrial features of CRCs organization, human resources, funds and demand. So, CRCs close to the “Public-Academic” pole (positive values of Factor 1) would be characterized by a greater “public presence” ─with greater public funding and higher share of public institutions in the CRC property─ and a greater “academic character” ─with a higher proportion of post-doctoral researchers and PhD students and a higher importance of basic research activities. Higher presence of post-doctoral researchers and PhD students would imply also greater attention to the creation and use of high-formed scientific human capital in the centre.

By contrast, CRCs close to the “Private-Market” pole (negative values of Factor 1) would be characterized by a greater “private presence” ─with greater industrial funding and higher share of private institutions in the CRC property─ and a stronger “market character” ─with higher importance given to the provision of technological applications and services and a stronger orientation to the economic benefits of their firm partners, customers and users. On the other hand, we could label Factor 2 under the name “Size of firm partners”, for which positive values show a stronger presence of small firm partners within the CRC and negative values indicate a greater presence of large firms.

Combining dimensions 1 and 2, we can finally suggest an empirical-based typology of Spanish CRCs. Of course, these types have to be understood as ideal and non-exhaustives. We disinguish four types of CRCs (Table 5):

- **Type 1**: This type of CRCs has a high proportion of small firm partners and a stronger public-academic orientation. Given the structural characteristics of the Spanish business sector, it is unlikely that this type is very frequent since in Spain, small firms ─with less than 50 employees─ represent 99% of the total number of companies (INE-base, 2012) and are characterised, among other features, by having a low rate of technological and innovative capacity and of qualified personnel, and a strong orientation to domestic and local markets (García-Delgado, 2011). If small firms join with universities and research centres, it is plausible that CRCs could apply academic specialised knowledge and skills to the local industrial needs. Consequently, we have called centres of type 1 “small potential innovators”.

- **Type 2**: This type of CRCs has a high proportion of large firm partners and public-academic orientation. According to a recent report of the General Directorate of Industry and SME of the Spanish Ministry of Industry (IPYME, 2013), large firms in Spain ─with more than 250 employees─ represent a minor percentage of the total number of companies ─hardly 0.12%─ but employ a great proportion of workers ─37%. Large firms also show high rates of technology capacity and innovation (García-Delgado, 2011). It is very likely that large firms that join CRCs with academic orientation ─like companies of this type─ have long-term objectives and more ambitious aims in terms of innovation, obtaining benefits from the knowledge created by post-doctoral researchers and PhD students. It is also plausible to think that transnational processes of creation and circulation of knowledge take place within this type of CRCs, since large firms in Spain are usually multinational companies. These characteristics would make CRCs of type 2 "transnational potential innovators".

- **Type 3**: CRCs of this type have a high proportion of small firm partners and private-market orientation. We expect this model of CRC to be the most common in Spain, given the structural characteristics of the Spanish business sector. Firms involved in CRCs of this type will probably have short-term objectives of production and more local and technical orientations. Given these characteristics we call CRCs of type 3 "Local technological developers".

- **Type 4**: CRCs of this type have a high proportion of large firm partners and private-market orientation. Similar to the firm partners of CRCs of type 3, it is likely that large firms involved in CRC of type 4 have also short-term and technical objectives of production, although their orientation will probably be more open to the international scope. So, we call CRCs of type 4 "Transnational technological developers".

Table 5: Suggested typology of Spanish CRCs

		Size of firm-partners	
		Small	Large
Public-academic vs. Private-market Orientation	Public-academic	***1. "Small potential innovators"***	***2. "Transnational potential innovators"***
	Private-market	***3. "Local technological developers"***	***4. "Transnational technological developers"***

Source: own elaboration.

To contrast our typology with the sectoral and regional affiliation of the centres, we group the CRCs of our sample according to the suggested typology. To this end, we first estimate the values of the factors for each case using an Anderson-Rubin procedure.[11] Table 5-A in the Annex shows the coefficients matrix for calculating factorial scores. Then, we apply a cluster analysis using the estimated factors as classificatory variables. We use a K-means procedure based on Euclidean distances and pre-fixing the clustering of CRCs into four groups.[12]

Table 6 shows the distribution of frequency of the resulting clusters. As expected, type 3 cluster —*"Local technological developers CRCs"*— is the largest one, corresponding to a half of the sample; and type 1 cluster —*"Small potential innovators CRCs"*— is the smallest one, only 10%. Clusters of types 2 and 4, both characterized by a high proportion of large firm partners, are equally distributed.

Table 6: Distribution of CRC clusters

Cluster	N	%
Type 1 *"Small potential innovators"*	9	10.0
Type 2 *"Transnational potential innovators"*	18	20.0
Type 3 *"Local technological developers"*	46	51.1
Type 4 *"Transnational technological developers"*	17	18.9
Total	**90**	**100,0**

Source: Own elaboration based on ES-CRCs Project data.

Regarding to the distributions of types of CRCs across sectors of economic activity and regions (Tables 7 and 8) we observe that there is a good fit between our typology and the sectoral and regional affiliations of CRCs. In both cases, the association index is significantly different to 0 and superior to 0.3, what means that, to some extent, there exists a relationship statistically significant between our suggested types of CRC and the sector of economic activity and region.

[11] This procedure guarantees that factors would be orthogonal one to one, also if they are built on an oblique rotation of the factor model. In order to manipulate and to interpret estimated factors, we transformed such values in percentages. Distribution of estimated factors is quite normal and without anomalous fashions.

[12] The algorithm reaches convergence quite easily, stopping at the step number 6 and without big differences between the initial and final centres of clusters (see Table 6-A in the Annex). Clusters are also sufficiently distant among them, as the value of the F-statistics is significantly different to 0 (see Table 7-A in the Annex). However, the centres of the clusters are not centred in the "heart" of any quadrant formed by the factorial axes (Graph 2-A). For example, we observe that the centre of "type 4 cluster" is closer to 0, while the centre of "Type 1 cluster" is the most distant to 0. Distribution of the centres of the clusters, as we said, is quite irregular. This is probably due to two reasons. First, we can see this result as a consequence of the oblique rotation of the factor matrix. The second reason is that type 1 is the most frequent case in our dataset, whereas type 1 the less frequent, as we will show now. The distribution of frequency of our clusters has a direct influence on the position of their centres.

Table 7: Distribution of CRC clusters by sectors of economic activities

Table 7a **Sector of economic activity (% Column)**	**Cluster**				**Total**
	Type 1 *"Small potential innovators"*	**Type 2** *"Transnational potential innovators"*	**Type 3** *"Local technological developers"*	**Type 4** *"Transnational technological developers"*	
Agriculture	11.1%	5.9%	10.9%		**7.9%**
High-Tech Industry	22.2%	70.6%	8.7%	17.6%	**23.6%**
Medium-Tech Industry			15.2%	29.4%	**13.5%**
Low Tech Industry	22.2%		30.4%		**18.0%**
Services (including ICTs)	11.1%	5.9%	28.3%	29.4%	**22.5%**
Energy, Water and Construction	33.3%	17.6%	6.5%	23.5%	**14.6%**
Total	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

Table 7b **Sector of economic activity (% Row)**	**Cluster**				**Total**
	Type 1 *"Small potential innovators"*	**Type 2** *"Transnationa l potential innovators"*	**Type 3** *"Local technological developers"*	**Type 4** *"Transnational technological developers"*	
Agriculture	14.3%	14.3%	71.4%		**100.0%**
High-Tech Industry	9.5%	57.1%	19.0%	14.3%	**100.0%**
Medium-Tech Industry			58.3%	41.7%	**100.0%**
Low Tech Industry	12.5%		87.5%		**100.0%**
Services (including ICTs)	5.0%	5.0%	65.0%	25.0%	**100.0%**
Energy, Water and Construction	23.1%	23.1%	23.1%	30.8%	**100.0%**
Total	**10.1%**	**19.1%**	**51.7%**	**19.1%**	**100.0%**
V = 0.426 (sig. = 0.000)					**N = 89**

Source: Own elaboration based on ES-CRCs Project data. Main observed relationships in grey.

Table 8: Distribution of CRC clusters by Region

Table 8a **Region (% Column)**	**Cluster**				**Total**
	Type 1 *"Small potential innovators"*	**Type 2** *"Transnational potential innovators"*	**Type 3** *"Local technological developers"*	**Type 4** *"Transnational technological developers"*	
Andalusia	11.1%	5.6%	23.9%	35.3%	**21,1%**
Basque Country	11.1%	38.9%	10.9%	5.9%	**15,6%**
Catalonia	11.1%	5.6%	17.4%	5.9%	**12,2%**
Madrid		22.2%	2.2%	5.9%	**6,7%**
Region of Valencia		11.1%	13.0%	5.9%	**10,0%**
Other regions	66.7%	16.7%	32.6%	41.2%	**34,4%**
Total	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

Table 8b **Region (% Row)**	**Cluster**				**Total**
	Type 1 *"Small potential innovators"*	**Type 2** *"Transnational potential innovators"*	**Type 3** *"Local technological developers"*	**Type 4** *"Transnational technological developers"*	
Andalusia	5.3%	5.3%	57.9%	31.6%	**100.0%**
Basque Country	7.1%	50.0%	35.7%	7.1%	**100.0%**
Catalonia	9.1%	9.1%	72.7%	9.1%	**100.0%**
Madrid		66.7%	16.7%	16.7%	**100.0%**
Region of Valencia		22.2%	66.7%	11.1%	**100.0%**
Other regions	19.4%	9.7%	48.4%	22.6%	**100.0%**
Total	**10.0%**	**20.0%**	**51.1%**	**18.9%**	**100.0%**
V = 0.495 (sig. = 0.042)					

Source: Own elaboration based on ES-CRCs Project data. Main observed relationships in grey.

In particular, we observe that CRCs of type 3 ─*Local technological developers"*─ mainly operate in Low-Tech industries (30.4%) and in the Service sector (28.3%) and CRCs of type 2 ─"*Transnational potential innovators"*─ mostly operate in High-Tech Industry (70.6%). However, CRCs of type 1 and 4 ─*"Small potential innovators" and "Transnational technological developers"*─ do not show any clear sectoral connection (Table 7a). Besides, CRCs operating in Agriculture mostly correspond to type 3 (71.4%) ─*"Local technological developers"*─ and all CRCs operating in Medium-Tech Industries (100%) are "technological developers", both local and transnational ─types 3 and 4 (Table 7b). We also note a strong correspondence between CRCs of type 2 and High-Tech Industry and between CRCs of type 3 and Low-Tech Industry and Services. However, other economic sectors like Energy, Water and Construction do not show any particular model of CRC (Table 7b).

By region, we find also some significant connections (Table 8a). For example, we observe that more than a half of CRCs type 2 ─"*Transnational potential innovators"*─ are located in Madrid (22%) and in the Basque Country (38.9%), while CRCs of type 3 ─*"Local technological developers"*─ are quite more distributed, although they are more common models in regions like Andalusia (23.9%) and Catalonia (17.4%). Besides, more than a third of CRCs type 4 is located in Andalusia (35.3%). However, CRCs of type 1 have no specific regional connection, but they are spread out across regions. These trends are confirmed if we look at the percentage distribution by regions (rows), although the relationship between Andalusia and type 4 CRCs become lower, due to the great diffusion of type 3 CRCs in this region. In addition, we note also a strong presence of type 3 CRCs in Catalonia and the Region of Valencia (Table 8b). Table 9 summarizes the main findings.

Table 9: Main findings on CRCs connections with sectors and regions

	Type 1 ***"Small potential innovators***	**Type 2** ***"Transnational potential innovators"***	**Type 3** ***"Local technological developers"***	**Type 4** ***"Transnational technological developers"***
Sector	-	High-Tech Industry	Agriculture, Low-Tech Industry and Service sector	-
Region	-	Madrid and Basque Country	Andalusia, Catalonia and Region of Valencia	Andalusia

5. Summary of results, discussion and future lines of research

This paper develops a typology of Cooperative Research Centres (CRCs) in Spain through the sectoral system of innovation (SSI) approach. According to this approach, and based on the Spanish CRCs experiences, our initial expectations were: (1) To find different types of Spanish CRCs according to their knowledge base, their basic technologies, inputs and demand characteristics; (2) to find some connections between specific types of CRCs and sectors of economic activity and (3) to find linkages between specific types of CRCs and regions in Spain. In order to perform the analysis, we use data from a survey directed to the heads of 123 CRCs in Spain (final sample).

Our research finds evidence that supports these three expectations. First, we suggest an empirical-based typology of CRCs in Spain that distinguishes four main types of centres: (1) "Small potential innovators"; (2) "Transnational potential innovators"; (3) "Local technological developers" and (4) "Transnational technological developers". The first two types (1 and 2) would have a knowledge base and human resources more academic and scientifically specialised, while the other types (3 and 4) would use a more technical knowledge and have a stronger industrial orientation. On the other hand, types 2 and 4 would have a greater proportion of large firm partners and a more open and international demand, while types 1 and 3 would have a greater proportion of small firm partners and a demand more domestic and local. Besides, we evidence some connections between types of CRCs and sectors of economic activity, finding that CRCs of type 2 ─"*Transnational potential innovators*"─ mostly operate in High-Tech Industries, while CRCs of type 3 ─"*Local technological developers*"─ mainly operate in Agriculture, Low-Tech industries and in the Service sector. Finally, our analysis finds also linkages between types of CRCs and regions, observing that CRCs of type 2 ─"*Transnational potential innovators*"─ are mainly located in Madrid and in the Basque Country; CRCs of type 3 ─"*Local technological developers*"─ are more common models in regions like Andalusia, Catalonia and the Region of Valencia, while CRCs of type 4 are mainly located in Andalusia.

Our suggested typology and findings are coherent with the structural characteristics of the Spanish economic sectors. For example, our analysis reveals that High-Tech Industry, characterised by having a high rate of innovation and productivity, mainly displays CRCs of type 2. We have called this type of centres "*Transnational potential innovators*" due to the high proportion of large companies among their firm partners and for their public-academic orientation. By contrast, Agriculture, Low-Tech industry and Service sectors, characterised in Spain by having a low rate of innovation and productivity, display mostly CRCs of type 3. We have called this type of centres "*Local technological developers*" due to the high proportion of small companies among their firm partners and for their private-market orientation. We observe that the size of the firm partners ─large vs. small─ shape to a great extent the characteristics, scope and orientation of CRCs in which they participate. It seems then that, although CRCs are "hybrid centres" between public-private and academic-market spheres, the private and market qualities predominate. More research is however needed. Further study of the characteristics and patterns of the firms involved in CRCs could shed more light to the understanding of such centres.

At the regional level, we also observe some coincidences among predominant models of CRCs by region, level of the regional R&D intensity[13] and regional CRCs initiatives and policies. For example, it is observed that CRCs of type 2 ─"*Transnational potential innovators*"─ predominate in Madrid and Basque Country, the two regions that, together with Navarra, show the highest R&D intensity in Spain (INE-base, 2012). In these two regions, public regional initiatives have recently promoted networks of new R&D centres for public-private cooperation created from scratch[14]. These centres are usually foundations supported by a unique regional program. However, in Catalonia and Region of Valencia ─regions with similar R&D intensities, lower than in Madrid and Basque Country─ the most common model of CRC is type 3 ─"*Local technological developers*". Unlike the Basque and Madrilenian cases, in these last regions CRCs are not created from scratch, but policies fostering private-public cooperation have mainly been based on pre-existing Technological Centres, closer to industrial needs and supported by local SMEs and governments.[15] An interesting line of research in this sense could be to systematically analyse how regional policies in Spain affect the institutional and organizational characteristics of CRCs. Another future research could undertake in depth the interaction between the sectoral and regional levels in relation to CRCs. Previous studies on the integration of industrial districts, regional and sectorial systems of innovation could be very useful in providing theoretical and methodological approaches to this end (for example, Gabaldón et al., 2012).

From a conceptual point of view, our study shows the suitability of the SSI approach to the study of CRCs. The sectoral system of innovation concept admits a wide set of elements ─such as the heterogeneity of agents and connections, the interplay of the sectoral and regional dimensions and the consideration of the different and varied factors surrounding innovation─ that fit very well with the CRCs characteristics of the Spanish case. In turn, the analysis of CRCs could also be used for advancing in the understanding of sectoral systems of innovation. Linkages emerged within SSIs include manifold market and non-market relationships among agents, artefacts and products. Since a CRC is essentially a formal non-market collaborative interaction among heterogeneous agents ─private companies, universities and research organizations, and government─, its study could help to apprehend and understand the emergence of new sectoral innovation dynamics.

Finally, the advance and improvement of our typology could have interesting applications for firms and policy decision-makers. In Spain, the R&D funding coming from industry is under the European average.[16] CRCs may be channels for firms in Spain to engage in Science, R&D and innovation and in this way, to be more

---

[13] R&D intensity considers the Gross Expenditures on Research and Development (GERD) as a percentage of the Gross Domestic Product (GDP) of the region. 2011 last available year INE-base.

[14] Within our simple of CRCs, 50% centres in Madrid and 57.1% in the Basque Country have this institutional affiliation.

[15] Within our sample of CRCs, 81.8% centres in Catalonia and 77.7% in the Region of Valencia have the institutional form of Technological Centre.

[16] For 2008 (last year available at INE-base), the contribution of firms to R&D investments was 54.8% for Spain and 63.6% for the UE-27 average.

competitive and productive. According to their size, needs, objectives and orientations, firms could decide to join one type of CRC or another. On the other hand, the participation of firms in CRCs could be an instrument for the creation of economic growth and employment. Public policy should consider promoting different types of CRCs according to the particular regional and sectoral peculiarities and to specific policy rationales. CRCs may appear as interesting means to get out of the current economic crisis.

References

Adams, P., R. Fontana and F. Malerba (2013) The magnitude of innovation by demand in a sectoral system: The role of industrial users in semiconductors, *Research Policy*, 42: 1-14,

Adams, J.D., Chiang, E.P and K. Starkey (2001) Industry-University cooperative research centres, *Journal of Technology Transfer*, 26: 73-86.

Arnold, E. Deuten, J. and van Giessel, J.F. (2004) *An international review of Competence Centre Programmes*, Brighton: Technopolis Group.

Atkinson-Grosjean, J., D.House and D. Fisher, (2001): Canadian Science Policy and Public Research Organizations in the 20th Century, *Science Studies*, 14 (1): 3-25.

Boardman, C. and D. Gray (2010) The new science and engineering management: cooperative research centres as government policies, industry strategies and organizations, *Journal of Technology Transfer*, 35: 445-459.

Bozeman, B., Dietz, J. and M. Gaughan(1999) Scientific and technical human capital: An alternative model for research evaluation, *International Journal of Technology Management*, 22: 716-740.

Chaminade and Edquist, (2005) From Theory to practice: The use of the Systems of Innovation. Approach in Innovation Policy, in J. Hage and M. Meeus (Eds.). *Innovation, science, and institutional change*: pp. 141-162. Oxford: Oxford University Press.

Cohen, W., R. Florida and W.R. Goe (1994) *University-Industry Research Centers in the United States*, Center for Economic Development, H. Jhon Heinz III School of Public Policy and Management, Carnegie Mellon University: Pittsbourg

CREST (2008): Industry led competence centres. Aligning academic/public research with enterprise and industry needs (Report of the CREST working group), OMC Action Plan.

Cruz-Castro, L. and L. Sanz-Menéndez (2007) New Legitimation Models and the Transformation of the Public Research organizational Field, *International Studies of Management and Organization* 37 (1): 27-52.

Diment, K. and S. Garrett-Jones (2007): "How demographic characteristics affect mode preference in a postal/web mixed-mode survey of Australian researchers", *Social Science Computer Review* 25 (3): 410-417.

Dosi, G. (1988) Sources, proceures and microeconomics effects of innovation, *Journal of Economic Literature,* 26 (3):1120-1171.

Etzkowitz, H. and L. Leydesdorff (2000) The dynamics of innovation: from National Systems and ''Mode 2'' to a Triple Helix of university–industry–government relations, *Research Policy*, 29: 109-123.

Faber, A. and T. Hoppe (2013) Co-constructing a sustainable built environment in the Netherlands—Dynamics and opportunities in an environmental sectoral innovation system, *Energy Policy,* 52: 628–638

Feller, I., C.P. Alies y J.D. Roessner (2002) Impacts of research universities on technological innovation in industry: evidence from engineering research centres, *Research Policy*, 31: 457-474.

Fernández-Esquinas, M. and I. Ramos-Vielba (2011) Emerging forms of cross-sector collaboration in the Spanish innovation system, *Science and Public Policy*, 38(2): 135-146

Gabaldón, D.; I. Fernández de Lucio and Molina, F.X. (2012) Sistemas Distrituales de Innovación, *Ciencia, Pensamiento y Cultura*, 188-753: 63-73

García-Delgado, J.L. (2011) *Lecciones de Economía Española* (10ª ed.). Civitas Ediciones.

Garrett-Jones, S. and T. Turpin (2010) Reward, risk and response in Australian cooperative research centres, *International Journal of Technology Transfer and Commercialisation*, 9 (1/2), 77-93.

Gray, D.O. (2011) Cross-sector research collaboration in the USA: A national innovation systems perspective. Science and Public Policy, 38:123–133

Gray, D. O., Lindblad, M. and J. Rudolph (2001) Industry-university research centres: a multivariate analysis of member retention, *Journal of Technology Transfer*, 26: 247-254.

Hayton, J.C., Sehili, S. and V. Scarpello (2010) Why do firms join consortial research centres? An empirical examination of firm, industry and environmental antecedents, *Journal of Technology Transfer*, 35: 494-510.

Howard Partners (2003) Evaluation of the Cooperative Research Centres Programme. Department of Education, Science and Training. Australia.

IPYME (2013) *Retrato de las PYME 2013.* Report of the General Directorate of Industry and SME. Spanish Ministry of Industry, Energy and Turism.

Kline, S. and N. Rosenberg (1986) "An Overview of Innovation", en R. Landau y N. Rosenberg (eds.), *The Positive Sum Strategy: Harnessing Technology for economic Growth*. Washington, D.C.: National Academy Press. Pp: 275-305.

Köhler, J., W. Schade, G. Leduc, T. Wiesenthal, B. Schade and L. Tercero-Espinoza (2012) Leaving fossil fuels behind? An innovation system analysis of low carbon cars, *Journal of Cleaner Production,* xxx: 1-11

Loasby, B. (2001) Time, knowledge and evolutionary dinamics. Why connections matter, Journal *of Evolutionary Economics*, 11(4): 393-412.

Malerba, F and L. Orsenigo (1999) Technological entry, exit and survival: an empirical analysis on patent data, *Research Policy,* 28: 643-660

Malerba, F. (2002) Sectoral Systems of Innovation and Production, *Research Policy*, 31: 247-264.

Malerba, F. (2007) Sectoral Systems: How and Why Innovation differs across Sectors, in Fagerberg, J. et.al. (Eds.) *The Oxford Handbook of Innovation*. Oxford: Oxford University Press.

Nelson, R. R. and S.G. Winter (1982) *An evolutionary theory of economic change*. Belknap Press.

Olazarán M., Albizu E. and B. Otero (2009) Technology Transfer between Technology Centres and SMEs: Evidence from the Basque Country, *European Planning Studies* 17: 3-23.

Oltra, V. and M. Saint-Jean (2009) Sectoral systems of environmental innovation: An application to the French automotive industry, *Technological Forecasting & Social Change,* 76: 567–583

Pavitt, K. (1984) Sectoral patterns of technical change: towards a taxonomy and a theory, *Research Policy,* 13: 343–373.

Potts, J. (2000) *The New Evolutionary Microeconomics. Complexity, competence and adaptive behaviour.* Edward Elgar.

Roessner, D. (2000) Outcomes and impacts of the State/Industry-University Cooperative Research Centres (S/IUCRC) Program.Final Report.

Santoro, M. D. and A.K. Chakrabartori (2001) Corporate strategic objectives for establishing relationships with University Research Centres, *IEEE Transactions of Engineering Management*, 48 (2): 157-163.

Tornatzfy, l.G., P.G. Waugaman and D.O. Gray (2002) Industry-University technology transfer: Models of alternative practice, policy and program. A benchmarking report of the Southern Growth Policies Board.

Turpin, T. and Garrett-Jones, S. (2010), 'Reward, risk and response in Australian cooperative research centres', *International Journal of Technology Transfer and Commercialisation*, 17.

Turpin, T., S. Garrett-Jones and K. Diment (2005) Scientists, career choices and organizational change: Managing human resources in cross-sector R&D organizations, *Journal of the Australian and New Zealand Academy of Management*, 11(2): 13-26.

Von Hippel, E. (1988) *The sources of innovation*. Oxford University Press.

ANNEX

Box 1-A: Sampling process and design

The survey was performed using a structured questionnaire directed to the heads of the Spanish CRCs. We used a postal/web mixed-mode technique (Diment and Garrett-Jones 2007): we sent an on-line questionnaire to centre's directors by email, accompanied by a postal letter informing about the aims of research. On-line access to questionnaire has been opened from August to October 2012. We sent 6 e-mail and 3 postal remainders to the centres. In addition, we performed also a telephone remainder using the CATI-system, for identifying specific response problems.

Previously to the survey, we identified the whole population of CRCs. In Spain, CRCs are quite recent an unexplored phenomena, so there is not any complete institutional directory of such type of organizations. In consequence, we built a map of R&D collaborative arrangements existing in Spain through a systematic review of secondary documentary sources of data, as R&D and innovation public programs and plans, institutional web directories of R&D organizations and the webpages of the research centres. We performed this search at both the national and regional levels. Through this documentary review, we identified a large set of R&D arrangements for cooperative research (234 cases).

Next, we selected a subset of research centres whose characteristics were consistent with a closer definition of CRC. This subset shapes the population framework of CRCs in Spain (163 cases). We decided to send the questionnaire to all these centres, without applying a sampling procedure based on probabilistic criteria. Then, the sample we obtained was a "strategic" sample of CRCs. We justify our choice due to the lack of knowledge about our units of analysis and the need of reach the whole population for identifying specific or problematic cases.

Table 1-A: Geographical distribution of CRCs in Spain

	Population		Sample		Difference	
	N	%	N	%	N	%
Andalusia	31	19.0	25	20.3	-6	+1.3
Basque Country	21	12.9	17	13.8	-4	+0.9
Catalonia	22	13.5	18	14.6	-4	+1.1
Madrid	15	9.2	10	8.1	-5	-1.1
Valencian Community	18	11.0	11	8.9	-7	-2.1
Other regions:						
Aragón	5	3.1	4	3.3	-1	+0.2
Asturias	8	4.9	6	4.9	-2	0
Baleares	6	3.7	6	4.9	0	+1.2
Canarias	6	3.7	4	3.3	-2	-0.4
Cantabria	2	1.2	2	1.6	0	+0.4
Castilla and León	3	1.8	1	.8	-2	-1.0
Castilla La Mancha	4	2.5	3	2.4	-1	-0.1
Extremadura	4	2.5	4	3.3	0	+0.8
Galicia	9	5.5	5	4.1	-4	-1.4
Murcia	2	1.2	2	1.6	0	+0.4
Navarra	4	2.5	2	1.6	-2	-0.9
Rioja (La)	3	1.8	3	2.4	0	+0.6
Total	**163**	**100.0**	**123**	**100.0**	**-40**	**0.0**

Source: Own elaboration based on ES-CRCs Project data.

Table 2-A: Correlation matrix

Variable (N of list = 90)	% Industrial property	% Public property	% Small firms	% Large firms	% Public subsidies on total budget	% Market incomes on total budget	% researchers with a PhD	% PhD students	Relevance of basic research	Relevance of technological services	Relevance of economic benefits for CRC partners	Relevance of economic benefits for customers and
% Industrial property	1	-.850**	.310**	-.398**	-.460**	.300**	-.395**	-.379**	-.259*	.336**	.334**	.092
% Public property	-.850**	1	-.349**	.449**	.533**	-.335**	.421**	.318**	.294**	-.320**	-.371**	-.178
% Small firms	.310**	-.349**	1	-.837**	-.183	.194	-.333**	-.224*	-.227*	.154	.158	.216*
% Large firms	-.398**	.449**	-.837**	1	.292**	-.278**	.430**	.259*	.359**	-.266*	-.271*	-.227*
% Public subsidies on total budget	-.460**	.533**	-.183	.292**	1	-.538**	.410**	.271*	.285**	-.340**	-.167	-.309**
% Market incomes on total budget	.300**	-.335**	.194	-.278**	-.538**	1	-.462**	-.284**	-.501**	.354**	.151	.322**
% researchers with a PhD	-.395**	.421**	-.333**	.430**	.410**	-.462**	1	.459**	.636**	-.569**	-.341**	-.378**
% PhD students	-.379**	.318**	-.224*	.259*	.271*	-.284**	.459**	1	.447**	-.465**	-.116	-.049
Relevance of basic research	-.259*	.294**	-.227*	.359**	.285**	-.501**	.636**	.447**	1	-.463**	-.145	-.305**
Relevance of technological services	.336**	-.320**	.154	-.266*	-.340**	.354**	-.569**	-.465**	-.463**	1	.129	.179
Relevance of economic benefits for CRC partners	.334**	-.371**	.158	-.271*	-.167	.151	-.341**	-.116	-.145	.129	1	.481**
Relevance of economic benefits for customers and users	.092	-.178	.216*	-.227*	-.309**	.322**	-.378**	-.049	-.305**	.179	.481**	1

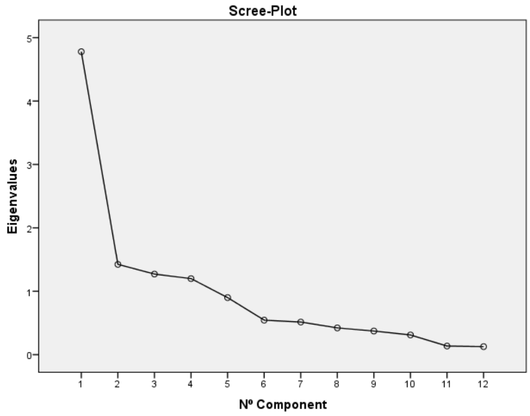
Source: Own elaboration based on ES-CRCs Project data.

Table 3-A: PCA Explained Variance

Component	Eigenvalues		
	Total	% of variance	% Acumulate
1	4.778	39.821	39.821
2	1.424	11.866	51.686
3	1.271	10.592	62.279
4	1.200	9.996	72.275
5	.900	7.501	79.775
6	.544	4.536	84.311
7	.515	4.288	88.600
8	.422	3.517	92.117
9	.372	3.104	95.221
10	.311	2.593	97.813
11	.136	1.132	98.945
12	.127	1.055	100.000

Source: Own elaboration based on ES-CRCs Project data.

Graph 1-A: PCA Scree-Plot



Source: Own elaboration based on ES-CRCs Project data.

Table 4-A: PCA Component Loadings

Variable	**Component**			
	1	**2**	**3**	**4**
% Industrial property	-.707	.242	-.333	.459
% Public property	.745	-.274	.229	-.452
% Small firms	-.557	.590	-.070	-.499
% Large firms	.679	-.513	.061	.417
% Public subsidies on total budget	.649	.126	.003	-.347
% Market incomes on total budget	-.606	-.349	.147	.020
% researchers with a PhD	.768	.242	-.116	.152
% PhD students	.577	.294	.370	.137
Relevance of basic research	.665	.394	-.044	.314
Relevance of technological services	-.621	-.413	-.170	-.108
Relevance of economic benefits for CRC partners	-.457	.265	.539	.298
Relevance of economic benefits for customers and users	-.454	-.012	.778	-.005

Source: Own elaboration based on ES-CRCs Project data.

Table 5-A: Coefficients Matrix for Factorial Scores (rotated model)

Variable	**Factor**	
	1	**2**
% Industrial property	-.138	.006
% Public property	.158	-.014
% Small firms	.163	.391
% Large firms	-.147	-.722
% Public subsidies on total budget	.170	.045
% Market incomes on total budget	-.174	-.060
% researchers with a PhD	.310	.077
% PhD students	.133	.037
Relevance of basic research	.204	.062
Relevance of technological services	-.197	-.071
Relevance of economic benefits for CRC partners	-.052	.006
Relevance of economic benefits for customers and users	-.069	-.010

Source: Own elaboration based on ES-CRCs Project data.

Table 6-A: Initial and Final centres of Clusters

Initial centres of clusters	Cluster			
	1	2	3	4
Factor 1	202.50	101.03	-197.69	-88.05
Factor 2	167.05	-133.48	-189.47	75.54
Final centres of clusters	Cluster			
	1	2	3	4
Factor 1	140.16	126.27	-77.58	-48.16
Factor 2	124.62	-99.45	-122.55	59.83

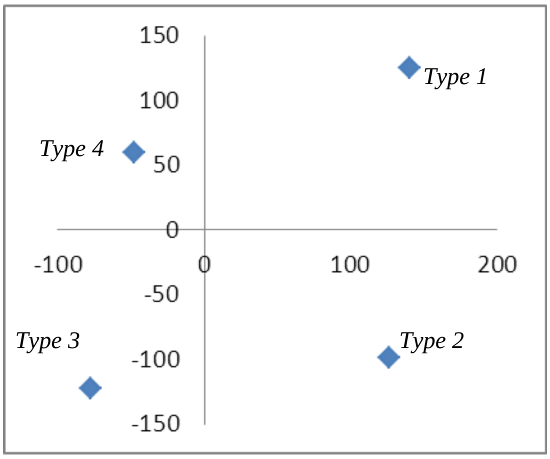
Source: Own elaboration based on ES-CRCs Project data.

Table 7-A: ANOVA of centres of Clusters

	Cluster		Error			
	Squared Mean	DF	Squared Mean	DF	F	Sig.
Factor 1	224262.625	3	2525.722	86	88.791	.000
Factor 2	245917.794	3	1770.310	86	138.912	.000

Source: Own elaboration based on ES-CRCs Project data.

Graph 2-A: Centres of the Clusters in the Factor Model Space



Source: Own elaboration based on ES-CRCs Project data.