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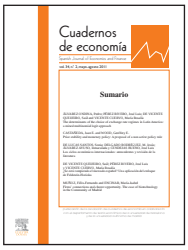

ARTÍCULO

Firms' connections and cluster opportunity. The case of biotechnology in the Community of Madrid

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Abstract Much of the Spanish biotechnology industry activity operates in the Community of Madrid (CM). Regional and local authorities are very interested in constituting a biotechnology cluster in the Community. All the necessary elements can be found in the region: as shown, there exists the opportunity for the emergence of a biotechnology cluster in CM. However, at the present time no biotechnology cluster can be said to exist as such in the region; there is only a *cluster opportunity*. In order to demonstrate this proposition, we provide an overview of the biotechnology industry, focusing on the firms that operate in Madrid and their connections between themselves and the other actors in the system. Any cluster strategy that aims to develop a biotechnology cluster in Madrid should consider the form of these connections.

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PALABRAS CLAVE
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Conexiones entre empresas y oportunidad de clúster. El caso de las empresas biotecnológicas en la Comunidad de Madrid

Resumen Buena parte de la industria biotecnológica española opera en la Comunidad Autónoma de Madrid (CAM). Las autoridades regionales y locales están muy interesadas en constituir un cluster biotecnológico en la comunidad. Todos los elementos necesarios para que pueda surgir dicho cluster están presentes en la región: como se muestra en este trabajo, existe la oportunidad para que emerja un cluster biotecnológico en la CAM. Sin embargo, no se puede afirmar con total seguridad que tal cluster exista por el momento en la región; tan solo hay una oportunidad de cluster. Para demostrar esta proposición, proporcionamos una panorámica de la industria biotecnológica centrándonos en las empresas que operan en Madrid y sus conexiones con otras empresas del sector y con otros actores del sistema de innovación. Cualquier estrategia que busque desarrollar un cluster biotecnológico en Madrid debería tener en cuenta la naturaleza de estas conexiones.

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1. Introduction

Most EU Member States are currently developing national and regional clusters as part of their policies to respond to the objectives of the Lisbon agenda. The European Cluster Observatory (ECO, 2010) has calculated that 38% of the European labour force work in enterprises that operate as part of a cluster. Moreover, the ECO has identified more than 2,000 regional clusters in 258 of the European regions that were analysed.

A cluster is formed by a group of enterprises, institutions and R&D organisations (such as research councils, public and private laboratories, etc.) that share experiences and best practices. They also cooperate on common projects and coordinate their operations. Furthermore, they compete with each other to develop a more favourable competitive framework for their activities. Thus, a cluster is based on cooperation and innovation, and one key condition for its success consists of reaching a critical mass of resources within a geographical location. For a cluster to emerge, collaboration between (a) firms, (b) universities and R&D organizations and (c) regional and local authorities is of great importance.

However, the definition of cluster or the extensive literature on clusters does not offer a clear guide or objective criteria for establishing the sectoral and spatial limits of an industrial cluster. For example, there is nothing that determines a priori the detail of either the sectoral disaggregation that needs to be considered or the kind and intensity of the links between sectors and firms for them to be elements of a cluster. Porter himself claims that the delimitation of a cluster is a rather subjective issue that depends on the judgment of the researcher. This judgment usually implies a creative process that is determined by knowledge of the connections (or links) and complementarities that exist between firms and institutions (Porter, 1998, p. 202). The same degree of inaccuracy appears in relation to the spatial or geographical boundaries of a cluster, although it is obvious that the geographical dimension is very important to the concept of cluster: "A concentration of rivals, customers, and suppliers will promote efficiencies and specialization. More important, however, is the influence of geographic concentration on improvement and innovation (Porter, 1990, p. 157).

Consequently, there is no unique guide that allows us to establish a priori whether the geographic boundaries of the clusters are more or less extensive, or in which spatial dimension (if any) the generating forces of a cluster should be operating (business linkages, externalities knowledge, pecuniary externalities, social networks, etc.). In the definition of cluster there is no explicit and precise reference to the degree of spatial density of the activities or the interactions between agents in a limited geographical space. It is impossible to set a priori a threshold from which objective conclusions can be drawn about the presence of a cluster. Therefore, the degrees of freedom of any cluster analysis have to be necessarily high.

These circumstances allow the researcher to establish a particular methodology that allows him to focus on the characteristics of the cluster that merit more attention in his opinion. In our case, we are specially interested in the connections of the different elements of a cluster with the firms that operate within it. We prefer to focus on firms because they are, in our opinion, the main actors in a cluster. Firms provide employment, incomes and profits, products and services and they materialise the competitive advantages of the cluster.

The main objective of this paper is to determine whether or not a biotechnology cluster exists in the Community of Madrid at the present time and, if not, to find the main reasons behind its non-emergence. To do so, we set up a methodology which focuses on the description of the existing connections between the elements that constitute a socio-economic system with a specific purpose (in this case a cluster in the Biotech industry). This methodology is complementary to the more traditional one based on Porter's work (in the context of the Institute for Strategy and Competitiveness), which is based on measurements of the concentration and intensity of intersectoral relationships.

The paper is organised as follows: in section 2 we provide an overview of the main characteristics of the Spanish Biotechnology System of Innovation, of which the Community of Madrid biotechnology industry is a part. The main result is that, on a relative scale, the Spanish system generates many scientific publications but not enough patents, incomes and firms. This is said to be a common paradoxical characteristic of the Spanish innovation system. In section 3 we characterise the biotechnology industry in the CM and analyse the existence of a biotechnology cluster. In order to do this, we focus on firms and their connections (with each other and with other actors in the region). We have employed different statistics, data sources and interviews. Section 4 is devoted to conclusions.

2. The Spanish Biotechnology System of Innovation: 'Many publications and few patents'

In this section we present an overview of the main characteristics of Biotech industry in Spain in the period 2000-2008. This is the common framework in which the different regional biotechnology concentrations of firms carry out their activities in Spain. Along with relative strength in scientific production, there is a marked technological and productive weakness. This gives rise to an apparent paradox: how can Spanish science be unable to generate a productive activity of a comparable level? Although we will not address this issue explicitly in this paper, some of the causes are repeated like a fractal dimension in the biotechnology industry of the Community of Madrid.

2.1. Business and financial relevance of the Spanish biotechnology industry

Biotechnology is an emerging sector in the Spanish economy. The number of companies completely dedicated to biotechnology (CDB), i.e. firms that carry out R&D

1. CMIB are firms with a consolidated activity in biotechnology either as their main industrial activity or as an activity that is well incorporated into company strategy. The firms with such an involvement may use the techniques of both modern and classical biotechnology in the preparation of products or processes. These firms are evolving into biotechnology through a process of industrial diversification. This terminology has been taken from Díaz et al. (2002).

activities or invest in Biotechnology, and companies mainly involved in biotechnology (CMIB)[1], i.e. those that perform activities linked to Biotechnology to a greater or lesser extent(industrial and commercial enterprises) with interests, developments, products and services based on biotechnology, have shot up 70% from 393 to 669 firms in the period 2000-2008 (Genoma España, 2009, p. 44).

By autonomous communities, there are more or less two CDB for each CMIB, except for Catalonia, which has a ratio of 3:1, and Andalusia, with 1:2 (unlike the other autonomous communities). In fact, Andalusia would appear to have a cluster of CDB (Genoma España, 2009). In any case, the autonomous regions with the highest number of firms are Madrid, Catalonia, Andalusia, Valencia and the Basque Country.

The most productive companies in the biotechnology industry (60% of total revenues) are devoted to bio-pharmacy and bio-industrial processes, although they only represent 40% of the companies and hire 45% of the total number of employees. These companies also generate 30% of the employment in development and technological services, although they represent only 15% of CDB with 15% of total revenues.

The number of companies dedicated to diagnostics and vaccines, agro-biotechnology and the food sector are numerous and have a high level of competence. They contributed with 11.5%, 8.4% and 2.4% of total revenues, respectively, in 2007 and employed 13.4%, 9% and 4% of the total employment ure, respectively. By sectors of application, CBD specialize in the subsector of developments and technological services (29%) while CMIB work in biopharmacy and account for 18% of said subsector. The industry as a whole represented 0.06% of the GDP in 2008 (this contribution is double the figure for the year 2000).

Revenues grew by 32.5% in the period 2000-2007 and the number of employees increased by 47.8%. Companies have an average of 15 employees each and their average revenue is €2.57 M per company.

So far, the public administrations have been decisive in the development of the sector and they have been a catalyst for private investment. Total public expenditure on R&D in biotechnology in Spain (including subsidies, grants and refundable credits) grew 22% per annum between 2000 and 2008 with a maximum public investment of €1,376 M in 2007. The available figures show that 65% of total investment in R&D comes from public funds and 75% of the research staff (including scientists and clinical personnel) also depend on public funds (13,800 people); the remaining 25% works in the private sector. In 2008, investments and total expenditure on biotechnology exceeded €1,300 M. The main financier of the sector is the Ministry of Science and Innovation with a maximum of €422 M in 2007; this amount fell to €362 M in 2008. The Ministry of Science and Innovation provides 70% of total public funds, followed by the autonomous communities (22%) and finally the EU (6%). By sectors, public subsidies to R&D go to human health (71.6%) followed by agriculture, livestock and fishing (12%). Public subsidies for innovation focus on food and beverages (40%) and human health (with 30.1 per cent).

In relation to external capital, Spain does not have a longstanding tradition of venture capital funding. Nowadays, there are 200 capital risk institutions operating in Spain and only 43 are pure venture capital firms (funding seed capital). Of these firms, 39 have been up and running since the year 2000 and 23 have less than five years of life. Many firms are still maturing their investments and have not completed any disinvestment processes. Most of them are yet to pass the test of raising a second-round fund.

€122 M of venture capital was invested in biotechnology between 2005 and 2008 (five times the sum for the period 2000-2004, but far removed from the order of magnitude of the EU-15 (€3,600 M in the same period) and the USA (10,000). Compared with other sectors of the Spanish economy, the venture capital funding in biotechnology in 2006 was an average of 2.8% higher than the EU-15; however this percentage fell in 2007-2008.

Most transactions are for small amounts (€0.5-3.5 M) and generally secured by a mix of public and private funds. TCD Pharma, a spin-off of the CNB, and Genmédica, a spin-off of the Barcelona Science Park, are two examples. It seems that there is lack of solid investment projects due to weak technological development. This circumstance must also be joined by the fact that Spanish biotechnological firms are not part of EURONEXT, the second market for capital in biotechnology.

2.2. The Scientific and Technological relevance of Spanish Biotechnology

Spain produces 3.2% of all scientific papers in biotechnology in the world and 8.5% of those in the EU. Spain occupied 5th place in the EU-15 ranking of scientific production in biotechnology in 2008, preceded by Germany, UK, France and Italy. However, in 2000-2008, Spain increased its scientific production by 47%, with an annual average growth rate of 6% (compared with an increase of 8% and an annual growth rate of 1% in the world and the EU-15). This is 6 times the EU-15 and world average. The percentage of the production of bio-science in Spain in relation to the total national academic production (weight) is on a level with Germany, France and United Kingdom.

Spain ranks 6th in the EU-15 in publications of papers in highest-impact factor journals. Spain's scientific papers that are not related to bio-sciences account for 5.1% of the EU-15 total, whereas Spanish scientists publish 8.5% of the EU-15's total papers in bio-sciences. However, only 16.61% of all scientific production in bio-science in Spain has a high-impact factor. Although countries such as Denmark, Sweden, Italy and Ireland, etc. have fewer articles than Spain, they achieve better impact factors for publications in bio-sciences. This phenomenon could be explained by a low level of interdisciplinary collaboration, difficult access to technologies and atomized research groups, etc.

In Spain, 25% of total scientific research in bio is horizontal, following human health (19%), industrial products (16%), and agrofood (14%). There is more cooperation with foreign research groups (41%) than with national groups (26%) and the rest (33% of research groups) do research without collaboration. The average size of research teams is of 4 members.

The number of employees engaged in R&D in biotechnology in Spain totals 18,000 (13,900 at universities, hospitals and public centres and only 4,100 at biotechnology companies). Since 2005, this number has increased 50%

in the public and private sectors. Researchers in public institutions account for 75% of the total. The number of contracts between universities and biotechnology firms grew 100% in the period 2000-2008 with the value of the contracts increasing more than 2.5 times. The average value of these contracts is approximately €30,000. There are also an increasing number of spin-offs from Spanish universities: between 13 and 15 new businesses created between 2006 and 2008.

Spanish institutions (universities, research councils, firms, etc.) doubled the number of patents requested at the OEPM in 2008 (200 applications in 2008 vs. 81 in 2000). The ratio of biotechnological patents to public researcher is 0.02, twice the figure for 2005 but a good distance from the figure for the EU-15. Spain ranks at position 11 in the EU-15 in European biotechnology patents granted, although it has improved its position somewhat, tripling from 0.18%in 2000 to 0.52% in 2007 (at EPO). Germany accounts for 14.32%, UK 6.05%, France 5.95% and the Netherlands 2.75% of total patents at EPO in 2008. The figures for patent applications at UPSTO are quite similar.

2.3. Spanish biotechnology: 'a lot of publications and few patents'

The figures show that there are many high-quality publications in Biosciences in Spain; despite this scientific production, the system seems to be incapable of generating enough economic value through the patent system. United Kingdom and Germany are the three top scientific producers in biosciences in the EU-15, and they are the first three countries in patents at EPO. Italy is the fourth country in bioscience in terms of scientific production in the EU; it accounts for 1.29% of the total number of European patents. Spain, which ranks 5th in scientific production in Europe, accounts for only 0.52 in terms of total EPO. The case with inventors is the same: 46.5 per cent of the Spanish inventors in Biosciences are working abroad and transfer the ownership of their inventions to foreign companies. Only 47% of Spanish inventors who are patent-holders live in Spain. The rest, more than half of the Spanish labour force with the capacity for patenting biotechnological innovations, live abroad and work for foreign institutions.

A more detailed look at the scientific production in Biosciences also shows that Spain is competitive in number, but not so much in quality (as measured by the percentage of papers in high impact journals). Only 16.61% of Spanish scientific papers in Bioscience have a high-impact factor vs. 27.85% in UK (which occupies first place in the ranking), the Netherlands (26.16), France (22.35), Belgium (22.28), Denmark, 19.78 and Italy (18.42).

For example, Holland ranks 6th in total production in the EU-15 (one position behind Spain); however, 26.18% of Dutch publications have a maximum impact factor. Accordingly, Holland ranks second in the EU-15 in terms of the quality of its publications and fourth according to the percentage of EPO patents granted (preceded by UK and Germany).

If we compare the production of scientific papers with a maximum impact factor with the total of each country of the EU-15, 8 out of 10 countries that produce fewer scientific papers in absolute terms than Spain have a greater percentage of high impact factor papers than Spain. In our opinion, this fact counters the apparent Spanish paradox: there is a (relatively) high scientific production, but it is not competitive enough. This (relative) weakness in research quality is important for understanding the low-level performance of the Spanish biotechnology industry.

To this state of affairs, we have to add that the public administration plays a key role in the development of biotechnology in Spain, since, in practice, it depends on public subsidies and credit, and that the financial and business relevance of biotechnology in Spain is very low-key at the present time. Thus, despite the growth of sectors such as biopharmacy and industry (mainly biofuels) and the increasing presence of biotechnology in the Autonomous Communities actually, there is relative strength in scientific production and an acute weakness in technology and production. In Spain, there is a new 10-year life industry that is small and not very relevant in terms of revenue and employment. It is seen by society as correct, politically protected, funded by public budgets and it has a scientific impulse that has not been developed enough to produce high quality research (but it is significant in terms of quantity). It also encounters serious difficulties for transforming the scientific production into market products and services.

The next two figures show the relative position of the biotechnology industry in Spain compared with USA and Germany. In Figure 1, we show the basic structure of the inputs of biotechnology firms, focusing on five items: Public R&D, R&D Expenditure, Employees in Biotechnology firms, PhD in Life Sciences and Venture Capital. In order make these figures comparable across countries, we construct an index in which 100 represents the maximum value of each of the items in the corresponding leading country. The relative position of each country then depends on the distance to 100 (the best country position benchmark). The figures refer to 2008 and are taken from Genoma España (2009).

Figure 1 shows the relative position of Spain: it highlights the huge difference in financial resources for biotechnology,

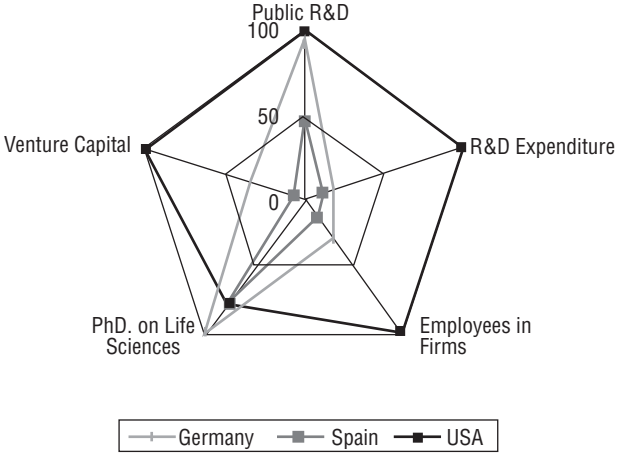

Figure 1 An international comparison of Spanish Biotechnology: inputs. Data: Genoma España (2009). Own preparation.

especially in R&D expenditure and Venture Capital, with 6.3 and 11.9, respectively, to 100 in both values for USA. Paradoxically, Spain generates almost the same number of doctors in Life Science (77.1) as the USA (77.6).

Figure 2 shows the situation of biotechnology in Spain in terms of output. Using the same methodology for Figure 2, we highlight six items: Scientific Production, PCT Patents, EPO Patents, Patents UPSTO, Revenues and Number of Firms.

Figure 2 shows a significant imbalance in the case of Spain that is also consistent with the above. Spain leads overall scientific production ahead of USA and Germany (Spain 87.5, USA 67.5, and Germany 63.5; although it is not shown on the graph, theEU-15 has a score of 100). There is no other data consistent with the (relative) dominant Spanish position in scientific production; the inability to generate market value in the form of patent output is particularly interesting. This is undoubtedly one of the most important issues when addressing a critical analysis of the position of the Spanish biotechnology industry.

Next, we shall see if the approach to the biotechnology industry in the Autonomous Community of Madrid, as a case study, provides us with an explanation of the above phenomenon.

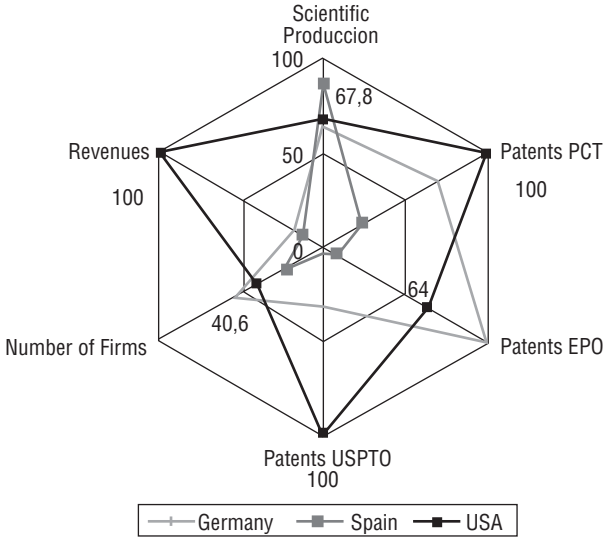

Figure 2 An international comparison of Spanish Biotechnology: outputs. Data: Genoma España (2009).

3. The case of Biotechnology in the Community of Madrid

Certain cumulative circumstances in the Community of Madrid make it a privileged place to develop biotechnology. The high number of research centres, research personnel, universities, chemical and pharmaceutical companies, a large hospital network and a financial centre makes the Madrid bio-region an exceptional location for activities in this industry.

The following two tables (Table 1 and Table 2) summarize the number of universities that offer bio-related training in the Community of Madrid, together with the number of doctoral theses read in this and other related areas.

With regard to scientific position related to bioscience, 31% of biomedical and health sciences publications are done in CM. Moreover 5,000 researchers in public research centres and Universities are located in Madrid. As shown, there were 223 new doctors at universities in Madrid in areas related to bioscience, pharmaceuticals and veterinary science in 2008.[2]

The main research centres in biotechnology in Spain also maintain their central offices in Madrid, such as the CNB (National Centre of Biotechnology), the CBM Severo Ochoa (a biological research centre of major importance in Spain), PCM (Madrid Science Park) in the UAM-CSIC international campus of excellence, the CSIC (the National Research

2. Data from Madrid Network (http://www.madridnetwork.org/Home.aspx).

Table 1 Number of centres where studies are offered by study, type and ownership

	Public Universities	Private Universities	Total
Biochemistry	3	—	4
Biotechnology	1	1	2
Biological Sciences	4	—	4
Chemical Sciences	3	1	4
Medicine	3	1	4
Pharmacy	2	2	4
Veterinary	1	1	2

Data: INE, 2010a. *University Education Statistic*.

Table 2 PhD Theses in bio-sciences. Academic year 2007-2008

	Biochem.		Biotech.		Biology		Chemistry		Pharmacy		Medicine		Veterinary	
	T	F	T	F	T	F	T	F	T	F	T	F	T	F
Alcalá de Henares	1	0			17	13	10	6	4	3	26	13		
Autónoma de Madrid					76	43	58	38			77	44		
Complutense de Madrid	13	10			79	47	33	17	29	21	52	28	17	7
Rey Juan Carlos					1	1	4	3	1	1	10	6		
Europea de Madrid											3			
San Pablo-CEU									6	4				

Data: INE. *University Education Statistic*. (T: total. F: females).

Council), the CNIO (Spanish National Cancer Research Centre), the foundations Genoma España, FECYT (the Spanish Foundation for Science and Technology) and COTEC, CDTI (Centre for the Development of Industrial Technology, responsible for credits for innovation), etc. It is also home to the major business associations (such as ASEBIO and Farmaindustria) and scientific associations (SEBIOT) in the sector, the Ministry of Science and Innovation, Madrid Network and IMADE, etc. Finally, Madrid is the country's financial capital. This gives it a great advantage over other regions in Spain.

3.1. The Bio-region of Madrid

The definition of cluster usually implies a geographical dimension. Proximity is a necessary condition (but it is not enough) in cluster analysis. Using data provided by ASEBIO and BioMadrid (2010), we have identified a total of 80 companies related to biotechnology in Madrid. We have plotted the location of these firms on a map (Fig. 3) of the Community of Madrid and we have used the post code of each firm to locate it in the region.

The main result shows that the companies are distributed geographically in such a way that there is less than an hour of transport distance between them. There are also three large concentrations marked as Zones A, B and C. Zone A is formed by Tres Cantos, a municipal district to the north of the city of Madrid; this zone includes 26 firms. Zone B is formed by 30 companies in the centre-north of the city of Madrid. Finally, Zone B includes two municipal districts: Alcobendas (7 firms) and San Sebastián de los Reyes (5 firms); these districts are very close to Madrid and Tres Cantos. However, the most important company by size, revenue, employment and patents is PharmaMar, which is located in Colmenar Viejo, a municipal district located away from the capital but on the border with Tres Cantos; we have marked it on the map as 'Ph.'.

The large concentration of enterprises in zone A is due to the location of the Madrid Science Park; most companies in this area are spin-offs or incubator firms. Furthermore, many of the biotechnology companies in Zone A (in the city of Madrid) are the central offices of large pharmaceutical firms or research institutions. In short, these areas identified as A, B and C on the map include 73 of the 80 biotechnology firms operating in the Community of Madrid.

In view of this map and considering that one of the elements needed to identify the existence of a cluster is the geographical concentration of companies, it can be said that there is a physical grouping of firms in the geographical area of the Community of Madrid. In other words, it meets the necessary condition for the existence of a cluster.

3.2. Analysis of the connections

Assuming that one necessary condition for a cluster to exist is the geographical grouping of companies, we have to examine whether there are indeed important connections between companies and between companies and other actors in the industry in this area to conclude that such a cluster exists. To do so, we have focused on the connections between companies and institutions that are close to each other in geographical terms.

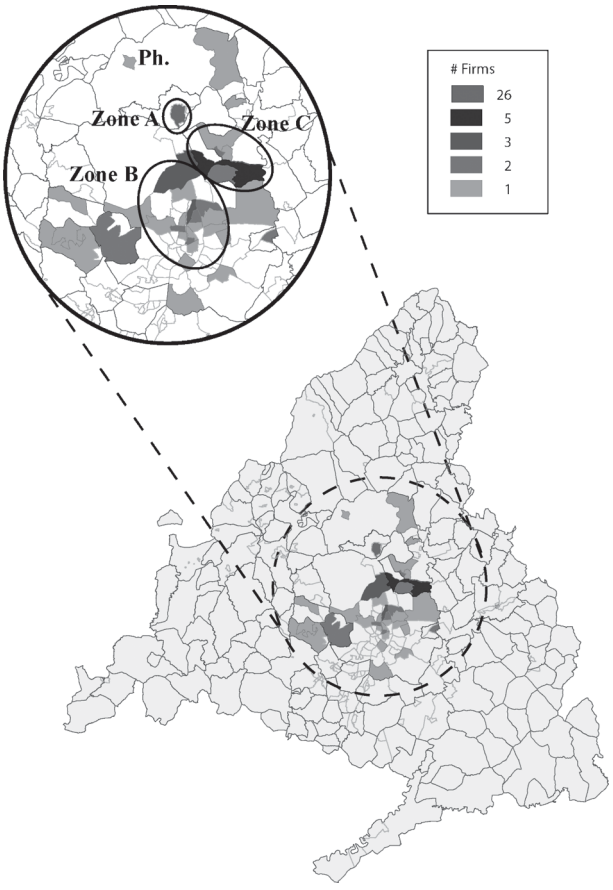

Figure 3 Map of Madrid Bio-Region (by post code). Own preparation.

Based on the perspective of the firms in the bio-region of Madrid, we explore the connections between different parts or elements of the biotechnology industry. To find them, we had to deal with a preliminary problem: the limits and extension of the population of the industry. There is no single list of enterprises that allows us to identify the whole population of this industry in Madrid. Thus, we have used a variety of sources: ASEBIO (Spanish Association of Biotechnology Enterprises), BIOMADRID (an association of the biotechnology firms located in Madrid), firms of PCM (2010) (Madrid Science Park), PITEC (2007) (a Technological Innovation Panel that includes a survey on 11,686 firms in Spain, drawn up by the INE [2010a], National Statistics Institute) and figures from *Module on the use of Biotechnology. Year 2007*, also drawn up by the INE (2010b).

Obviously, there is no unitary statistical criterion and, accordingly, we have performed a mix of several aspects from said different sources. The use of different information sources has led us to construct a statistical population of 80 biotechnology-related companies in the Community of Madrid, 17 of which are also included in the Madrid Science Park (they are classified as Life Sciences or Chemical firms).

To identify the connections in this population of 80 companies, we have analysed the information the companies provide on their websites. Figure 4 shows information about the connections provided by the firms on their websites.

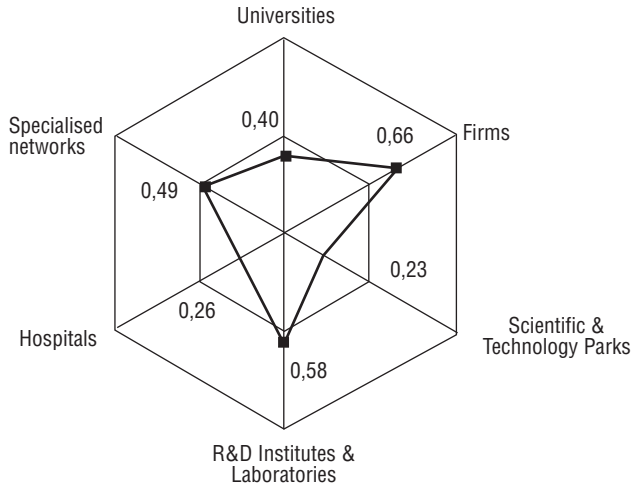

Figure 4 Connections of biotechnology firms in CAM. Own preparation from the firms' websites.

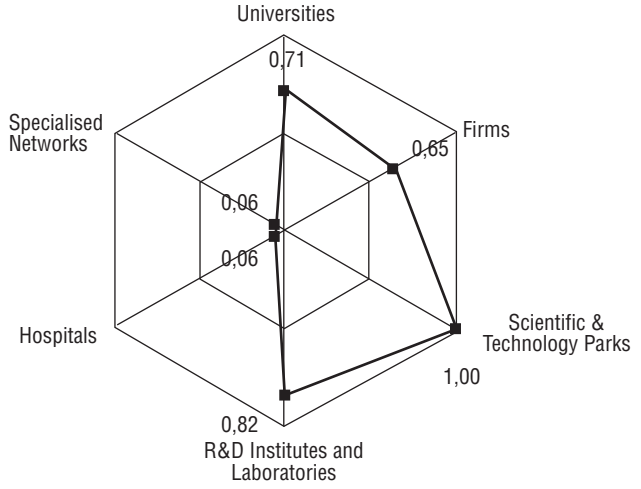

Figure 5 Connections of biotechnology firms in PCM. Own preparation. Data from PCM.

We have also defined a subset of the previous population that contains 17 companies located in the Madrid Science Park. We have gathered this information using the questionnaire shown in Appendix 1.[3]

Comparing Figures 4 and 5, the following prominent features are observed. The PCM subset (Fig. 5) has more connections with institutes and laboratories, followed by connections with universities. However, the connections highlighted by the companies themselves (Fig. 4) on their websites are mostly with other companies, followed by institutes and laboratories, but with nearly 30% less incidence of this kind of connection than in the case of companies located in PCM. Moreover, Figure 4 shows that relationships with the University are much less frequent

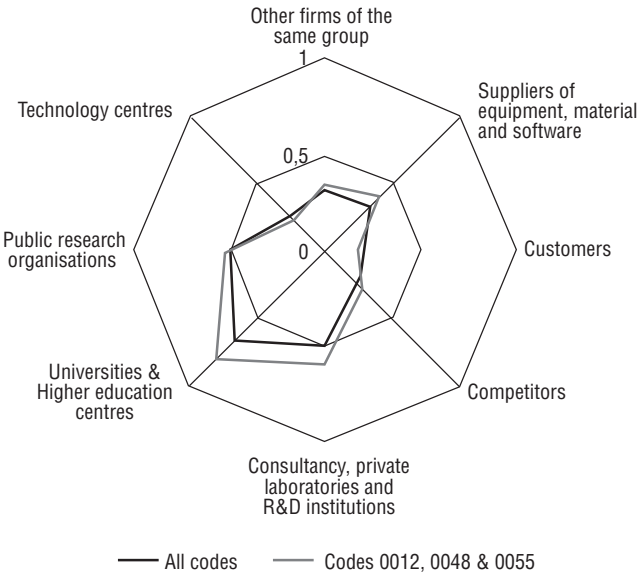

Figure 6 Connections of biotechnology firms in CAM using PITEC data. Own preparation using data from source: PITEC 2007. See codes in Appendix 2.

than in the case of companies that are part of the PCM (0.40 versus 0.70).

Figure 5 also shows that there are very few connections between PCM firms and hospitals and specialized networks while in the case of companies in general (Fig. 4) they seem to mention this kind of connection more frequently.

In view of both figures, we could conclude that the companies belonging to the PCM (most of them spin-offs) focus more on connections with academic institutions or universities. However, companies in general have a more multi-relational profile with less intensive connections that are more extensive with different types of agents. According to their own figures, the subset of PCM firms has more intensive relations but it seems (said with reservation) that they are less connected with other companies, networks and hospitals.

3.3. The connections of biotechnology firms in PITEC

It is very interesting to compare the previous results with the statistics provided by the PITEC panel data.[4] In this work, we have used PITEC data referred to the year 2007, which is the last available year at the present time.

In order to identify the main characteristics of the companies operating in the Community of Madrid, we have begun to extract the companies that have declared that

3. This questionnaire has been drawn up by the authors. The PCM personnel have included some of the questions in their annual report.

4. The Technological Innovation Panel (PITEC) is a statistical instrument for studying the innovation activities of Spanish firms over time. PITEC is designed as a panel survey. The data base is being built by the INE (National Statistics Institute). PITEC applies an anonymization process to replace the firm-level observations of six quantitative variables (Turnover, Exports Investment, Number of employees, Innovation expenditures and Number of R&D employees). The PITEC sample for 2007 includes 11,686 firms.

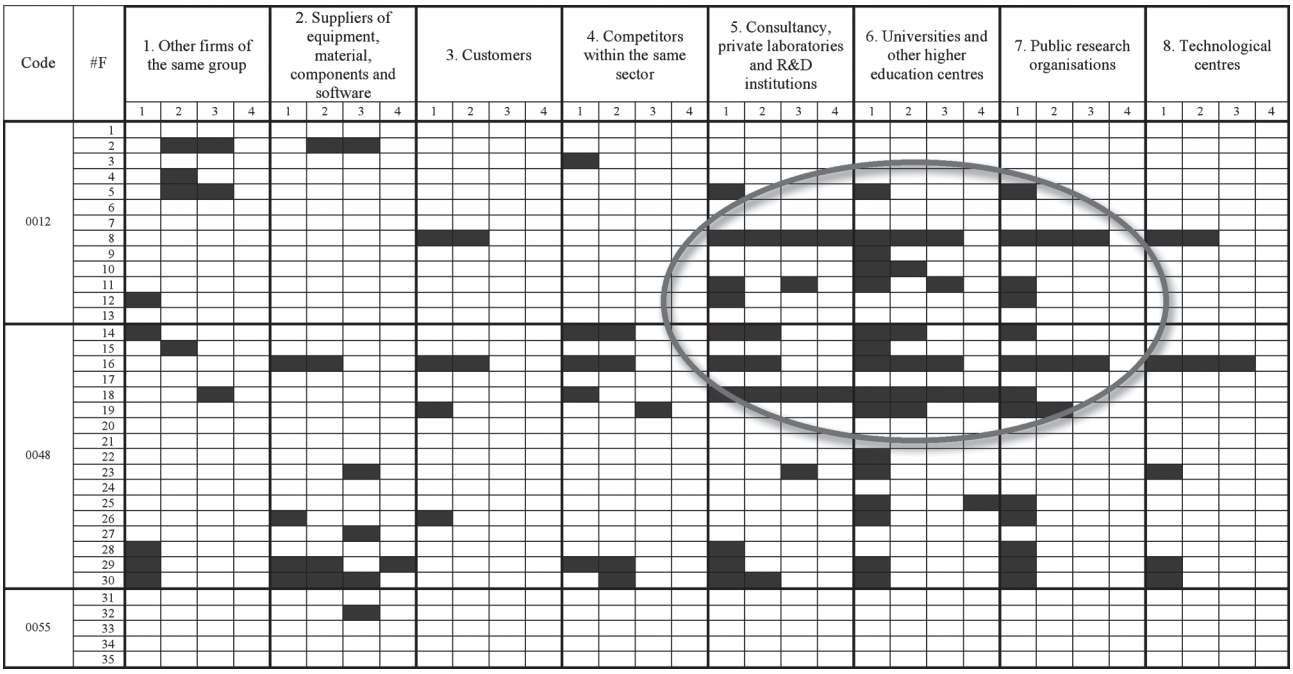

Figure 7 The connections of biotechnological firms in the Community of Madrid. Own preparation using data from PITEC 2007. See PITEC codes correspondence with NACE-93 in Appendix 2. Legend: #F: number of the firm ordered by NACE codes and revenue. Location of the cooperative agent: *i*1: the same country; *i*2: other European country; *i*3: USA; *i*4: rest of the world.

they work in biotechnology or related activities in the Panel (according to NACE-93 codes). The number of companies after using this filter totals 401 companies nationwide. In panel 60, we have later identified companies in what might be called a bio-region of Madrid (using the geographical criterion defined as 'belonging to the Community of Madrid').

With regard to collaboration, if we extract the data belonging to firms that have declared that they work in biotechnology or related activities from the PITEC panel, the companies reveal the following pattern of collaboration.

The pattern of connections of the innovative companies in PITEC (all companies) is not very different from the pattern of biotechnology-related companies; in particular, the firms associated with codes 0012, 0048 and 0055.[5] This is the case with regard to connections with technology centres, other firms in the same business group, suppliers of equipment, material and software, public research centres and customers. However, we find a notable difference in connections with universities and other higher education institutions (67% all vs. 80% in the case of the selected subset) and consultancy firms and private R&D laboratories and institutes (50% and 60% respectively).

This seems to suggest that while the companies most closely related to biotechnology maintain a pattern of connections quite similar to the rest of Spanish innovative companies, the connections with universities and research centres are much more intense in the case of biotechnology firms.

Focusing specifically on the subgroup of companies classified with PITEC codes 0012, 0048 and 0055, we obtain Figure 7. This figure gives a more accurate view of the pattern of connections of this sample of firms.

The figure is built as follows: each row represents a firm (anonymized), grouped by its corresponding PITEC code and ordered from higher to lower revenue. The figure also has 32 columns distributed in 8 groups, depending on the type of agent with which a company can establish some kind of collaboration. Within each group there are four columns, since the agent that cooperates is located in Spain, another country of the EU, USA or the rest of the world. A shaded box means that there is cooperation; a blank box means no cooperation.

There are several elements in Figure 6 that are worthy of comment. First of all, 13 of the 35 companies in the table (those grouped under 0012, i.e. pharmaceutical firms) have an average revenue of €246 M compared to the €20.3 M of the 17 R&D firms (included in 0048). This implies that the former have an average revenue that is 11 times higher than the latter. Pharmaceutical companies spend 4.74% of their revenues on internal R&D versus the 33.85% spent by R&D firms. In other words, the latter spend 8 times more on R&D than the former in spite of their differences in revenues. If we compare the percentage of internal R&D expenditure with total R&D expenditures, pharmaceutical companies (0012) spend 64.65% of their total R&D expenditure on internal R&D and companies in group 0048 spend 68.92%.

As far as the connections are concerned, column *i*4 ($i = 1, \ldots 8$) is practically blank, i.e. there are no connections with agents other than 1, 2 and 3 (in other words, besides the EU and USA the firms in this sample have no links with the rest of the world).

5. See the correspondence of PITEC codes with NACE-93 codes in Appendix 2.

In subgroup 0012, there are four firms (see rows 1, 6, 7 and 13) that do not collaborate with any type of agent represented in the columns of the table. This is also the case with two companies (rows 20 and 21) in subgroup 0048.

However, firm number 8 in group 0012 shows an important density of connections with other companies in the same group. Together with the following four, this firm makes up the core of the stronger connections in the subsector of pharmaceutical firms. The greater intensity and agglomeration of connections is established with Consultancy, Laboratories and R&D institutions, Universities, Public Research Organisations and Technological Centres. As regards the firms in group 0048, the core of connections includes companies 14 to 19; moreover, the pattern and intensity of connections focus on agent groups 5, 6, 7 and 8 (see these columns). This agglomeration (marked with a red circle) could be the germ of a biotechnology cluster in the Community of Madrid beyond corporate spin-offs or incubator firms located in PCM. In any case, this group has the highest density of links with groups 5-7, not with other firms, suppliers, customers and competitors, i.e. the market side of the cluster.

However, the companies with more intense and frequent connections are somewhat different. In this subclass, the pharmaceutical firms are companies with revenues ranging from €106 M to €3 M. The revenues of R&D firms range from €121 M to €4.4 M. Finally, group 0055 is irrelevant for the purposes of this analysis.[6]

3.4. Regional Specialisation Index

The PITEC panel also allows us to analyze the degree of specialization of the Community of Madrid in biotechnology and compare it with other Spanish regions and the evolution of employment in this industry in full-time equivalent units (FTE). Starting with the degree of specialization, the figures for 2007 are presented in Table 3.

As in the former case, we begin with a sample of 401 companies that have declared that they work in biotechnology (or related activities) in Spain; we have extracted those with personnel involved in R&D activities in the autonomous communities with more weight in this industry: Andalusia, Catalonia, Madrid and the Basque Country. The Index of Specialisation measures the proportion of employees involved in biotechnology R&D activities (in FTE units) in an Autonomous Community to total employees involved in R&D activities (in FTE units) in said Autonomous Community.

The table shows that 8.57 of every FTE 100 employees in innovative companies work in biotechnology related companies in the Community of Madrid. This figure has increased since 2005 (7.04) and 2006 (7.82), where the total employment in biotechnology in 2006 was 1,325.35 FTE in Madrid with a total of 16,958 innovative companies in the region.

The Spanish region with the highest degree of specialization in biotechnology is Catalonia due to the strong presence of pharmaceutical industries in the region, as well as the existence of frontline hospitals and universities; its research tradition is also more important than that of Madrid. The index of Andalusia should be interpreted carefully in the light of the relatively low total number of researchers in biotechnology and other activities. The value of the index in the Basque Country is remarkable because it is a region with a longstanding tradition, especially in industrial innovation, and it is a pioneer in the creation of technological clusters in Spain.

3.5. Is there a biotechnology cluster in the Community of Madrid at the present time?

Assuming that one necessary condition for a cluster to exist is the geographical grouping of companies, we focused on the connections between companies and between companies and other actors in the industry in the area in order to decide if a cluster actually exists. Thus, we have analysed the connections between companies that are geographically close to each other and institutions in the Community of Madrid.

From the above analysis, we can conclude that there is no biotechnology cluster, as such, in the Community of Madrid at the present time. We have showed that the (relative) predominant CM position in scientific production goes hand-in-hand with the inability to generate market value in the form of patent output, products and services (using revenues as a proxy) and the economic relevance of the biotechnology industry in the region.

Our approach to the industry of biotechnology in the Community of Madrid provides us with an explanation of the phenomenon described above: the group of firms that has the highest density of connections (with agents classified in groups 5-7 in Fig. 7), reveal very weak connections (if any)

6. The degree of concentration of revenues in biotechnology companies located in Madrid (by PITEC) is very large. 20% of the companies account for 87% of the total revenues. The same applies to the concentration of personnel involved in R&D: 20% of companies accounted for 80% of researchers.

Table 3 Regional Specialization Index in Biotechnology (2007)

	Biotech PR&D	Total PR&D	Index of Specialis.	% PR&D biotech Reg/Spain	% PR&D Reg/Spain
Andalusia	509.77	3,496.28	14.58	7.60	5.62
Catalonia	2,356.06	15,775.28	14.94	35.13	25.37
Madrid	1,350.75	15,754.33	8.57	20.14	25.34
Basque Country	888.55	9,494.52	9.36	13.25	15.27
SPAIN	6,706.67	62,182.16	10.79	100.00	100.00

Own preparation using PITEC 2007 data. PR&D: personnel in R&D. Units: FTE.

with other firms, suppliers, customers and competitors in the same industry; in other words, the main weakness arises on the market side of a cluster.

4. Concluding remarks

The main conclusion drawn from this paper is that there is no biotechnology cluster as such in the Community of Madrid at the present time. The weakness of the existing connections between firms in the industry and between the business sector and the other biotechnology players supports this conclusion.

However, the region has all the elements required to configure a cluster: public and private high-level scientific research institutions, a powerful and sophisticated financial organization, an important number of universities and doctors in Life-sciences, etc.

Moreover, the regional authorities have the political desire to set up this cluster. This is the case of the recent regional Madrid-Network initiative, whose projects include the so-called *Biocluster Madrid*, which aims to build a cluster that exploits the potential of actors present in the CM. There is also a cluster strategy (at least the new player has one). The originality of Biocluster Madrid's approach consists of founding the cluster strategy on a business strategy (at the level of the actors involved, mainly the firms) instead of focusing on a more scientific-academic approach (as has usually been the case in Spanish cluster experiences).

Therefore, although we cannot speak of a biotechnology cluster in the CM, there is a real opportunity to create one. The main challenge is the generation of spaces and strategies for cooperation between the different actors involved in the industry and operating in the region of Madrid. These strategies must enhance the connections that are more concerned with markets (groups 1-4 in Fig. 7). The low density of this type of connection is probably a consequence of the fact that most pharmaceutical companies in Madrid are subsidiaries of multinationals and that R&D companies were incorporated or continue to exist thanks to subsidies from universities and public institutions.

Finally and from a purely theoretical point of view, this work shows that the density and character of the connections between the constituent elements of the system are essential to understand the dynamics and efficiency of a system of innovation in particular (Encinar and Muñoz, 2008) and of a cluster more specifically.

Of course, this work is mainly descriptive: it is very important to have a first picture of the biotechnology industry in CM before designing and/or applying any cluster policy or cluster strategy in the region. The analysis is not dynamic because we do not have a long enough time series for more general and dynamic research (at the empirical and theoretical levels). Such a dynamic analysis is needed for a better understanding of the elements that enable the emergence, consolidation, and performance of a cluster.

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Appendix 1. Questionnaire used for the analysis of connections of Madrid Biotechnology firms. Own preparation

Firm		
URL		
Collaborations with:	• Universities:	.....
	• R&D Institutes:	.....
	• Laboratories:	.....
	• Science Parks:	.....
	• Technology parks:	.....
	• Cluster organisations:	.....
	• NGOs:	.....
	• Chambers of commerce:	.....
	• Specialised networks:	.....
	• Public agencies:	
	— state	.....
	— regional	.....
	— local	.....
	• Other firms:	.....
	• Other (mass media, venture capital, etc.):	.....
Profile:	1. Was it incorporated as a spin-off? ❒ Y (please specify the current phase): ❒ N	
	2. Was it incorporated as a subsidiary of a multinational?	❒ Y ❒ N
	3. Other:	.....
	4. The location of the firm is linked to:	
	— Natural resources	❒ Y ❒ N
	— University	❒ Y ❒ N
	— Science Park	❒ Y ❒ N
	— Technology park	❒ Y ❒ N
	— Entrepreneur residence	❒ Y ❒ N
	— Other:	.....
	5. Access to Venture Capital:	❒ Y ❒ N
	— Financial	❒ Y ❒ N
	— *Skills*	❒ Y ❒ N
	— Consultancy and advice	❒ Y ❒ N
	6. Connections with international markets (materials, components, new technologies, brain circulation, etc.) Please specify:	❒ Y ❒ N
Pipeline/ Patents		....

Appendix 2. Correspondences of PITEC codes with NACE-93 codes

PITEC code		NACE 93 code
0012	Pharmaceutical products	244
0048	Research and Development	73
0055	Other health, social and collective services	80 (excl. 803), 85, 90, 91, 92 (excl. 921, 922), 93