INNOVATION.

CITY AND COMPETIVENTESS: BARCELONA AND EUROPEAN METROPOLITAN REGIONS

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It is unquestionable that in recent years there has been a tendency towards the agglomeration of the population and activity in cities, both in Europe (Eurostat, 2016) and on a global scale (UN, 2017, Florida, 2017). Although this paper does not intend to make a historical analysis of the phenomenon, it is interesting to locate the beginning of this trend at the time of the industrial revolution (18th century). During that time efficiency gains due the concentration of the production in large productive establishments (economies of internal agglomeration) led to the concentration of population and workers in specific locations (OECD, 2015, Piore and Sabel, 1984). More recently, the industrial crisis of the 1970s and the suburbanization process put this agglomeration process in question and, together with the ICT revolution of the 1990s, there was speculation about the loss of importance of the physical agglomeration (it was said that there was "death of distance" [1] and that the "world had become flat" [2]). Nothing is further from reality. At the same time there was a shift in the paradigm of how advanced economies worked that highlighted the importance not so much of "what is done" but of "how it is done". In the "how", the key competitive factor is none other than knowledge: it is the knowledge economy (OECD, 1996). And it is in the cities -in the agglomerations of population and activity- where knowledge is created, developed and integrated into local economic production (Becattini, 1979 and 2015, Trullén et al., 2013, Camagni, 2016). As the economic theory highlights, knowledge is a non-rival good and as such it is subject to increasing returns (Romer 1986 and 1990), so that cities -dense metropolitan environments- acquire a special importance in the knowledge economy.

In this paradigm, innovation is one of the fundamental determinants of development and competitiveness. Although it is not an objective in itself, the importance of innovation lays in the fact that it is a source of new activities, new jobs and productivity growth and, consequently, economic growth, development and well-being. Innovation is mainly concentrated in cities that, as mentioned, are increasingly more relevant in economic terms, since they increasingly concentrate population and economic activity. Consequently, cities are the fundamental element for innovation but also for improving the GDP and the welfare of the population.[3]

1 "The Death of Distance" was the title of a telecommunication supplement in the British weekly magazine The Economist on September 30, 1995 (Vol 336, No. 7934).
2 T. Friedman (2007). The World is Flat. The Globalized World in the Twentieth-First Century. England: Penguin.

3 The process of urbanization is a very complex process involving many factors with different results; however this article only covers a limited part of the economic dimension. As an example of this variability, there are two books by two of the most recognized experts in the international academic field: Triumph of the city: How our greatest invention makes us richer, smarter, greener, healthier, and happier, Edward Glaeser, and The New Urban crisis. Gentrification, housing bubbles, growing inequality, and what we can do about it, by Richard Florida.

In an urban economy, analyzing the city or the metropolis in terms of administrative units is insufficient and, therefore, it is necessary to consider the whole of the functional city. Nevertheless, in applied terms, there is a difficulty in that there is neither a single definition nor a single methodology for identifying this city or metropolitan area. To overcome this drawback, in this paper it has been decided to use the metropolitan regions defined by Eurostat as an approximation of the functional city. These regions have the advantage of allowing international comparisons and the use of indicators from different statistical offices or international databases.

The objective of this paper is to answer three relevant questions from the point of view of cities and innovation. First, checking if population, economic growth and innovation are increasingly concentrated in cities and metropolitan regions. Secondly, for the closest case of Catalonia, verifying that innovation is concentrated mainly in the centre of the metropolis or metropolitan region and identify the technological profile of the province of Barcelona. Third, to the extent that technological innovation has to serve to improve the competitiveness of companies, identifying if there is any correspondence between the main technological sectors by number of patent applications and the main export sectors.

The paper is divided into six sections. After this introduction, the second section studies the evolution of population, the GDP and the innovation in the metropolitan regions of the EU-28 and in particular how the 25 regions with the highest GDP have behaved. The third section analyzes the evolution of European patents in Catalonia and its provinces. In the fourth section, the interior of the province of Barcelona and its technological specialization are analyzed. The fifth section analyzes the relationship established between the main technological sectors by the number of patent applications and the main export sectors. Finally, in the last section some brief conclusions are presented.

Population concentration, GDP and innovation in European regions

In this section we want to see what is the recent evolution in Europe (EU-28) in terms of population and GDP, if it confirms the trend towards concentration, and to what extent this concentration also translates into a concentration in innovation, measured in European patents.[4]

, The metropolitan regions defined by Eurostat have been used for the elaboration of this section. The metropolitan regions are made up of one or more NUTS 3[5] regions that represent agglomerations of at least 250,000 inhabitants. Each metropolitan region is made up of at least one NUTS 3 region. But it must be borne in mind that if more than 50% of the population of an attached NUTS 3 region also lives within the agglomeration, it is included in the metropolitan region.[6]

The following map presents these metropolitan regions; as can be seen, they are distributed throughout all the EU-28 countries, although there seems to be a higher concentration in the central area of the EU. You can also see how some these metropolitan

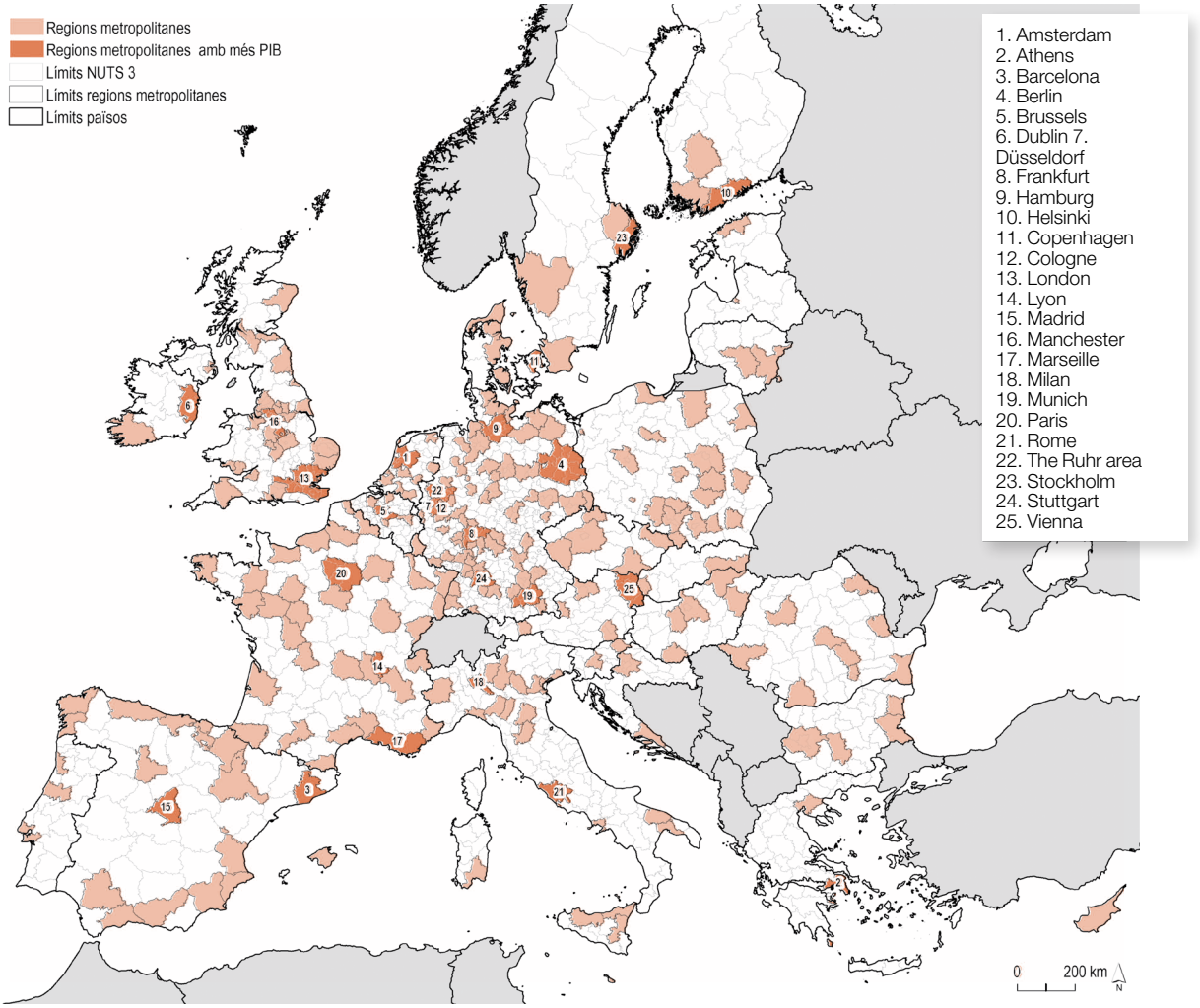
4 European patent applications are used in this paper. This is because their geographic scope and cost are considered to reflect high quality innovations. For an analysis of Spanish patents (OEPM) see Trullén (2014); for North Americans (USPTO), see Galletto (2015).
5 In the case of Spain, they would be the equivalent of the provinces.
6 These agglomerations were identified using the functional urban area (FUA) prepared by the Urban Audit.

Table 1.Population, GDP in millions of Euros and European patents by inventor's address, in absolute value and in percentage on the EU-28, 2017 (or last year available)

				In% of the EU-28		
	Population (2017)	GDP M € (2015)	European patents (2014)	Population (2017)	GDP M € (2015)	European patents (2014)
Metropolitan regions	297.617.816	9.931.944	38.980	58	67	71
Non-metropolitan regions	213.904.855	4.865.500	16.070	42	33	29
EU-28	511.522.671	14.797.444	55.050	100	100	100

Source: IERMB based on data from Eurostat and OECD, REGPAT database, March 2018.

Map 1 Identification of the metropolitan regions of the EU-28



Source: IERMB based on Eurostat data.

regions are made up by more than one NUTS 3, as are the cases of Berlin, Paris and London, among others.

According to the most recent Eurostat data, the number of metropolitan regions in the EU-28 is 267, which includes 527 NUTS 3 (representing 39% of the total NUTS 3). The population that lived in these metropolitan regions in 2017 was 298 million, which represented 58% of the total population of the EU-28. In terms of GDP, these regions represented 10 billion Euros in 2015 (the last year for which data was available for all regions), a figure that represented 67% of the European total. In terms of innovation, measured in European patents registered by the EPO (European Patent Office), in the metropolitan areas there were 38,980 patents in 2014 (the last year for which data was available for all regions), which represented 71% of the European total (see table 1).[7]

If we analyze the evolution of the European metropolitan regions (EU-28), we observe that the weight of the population over the

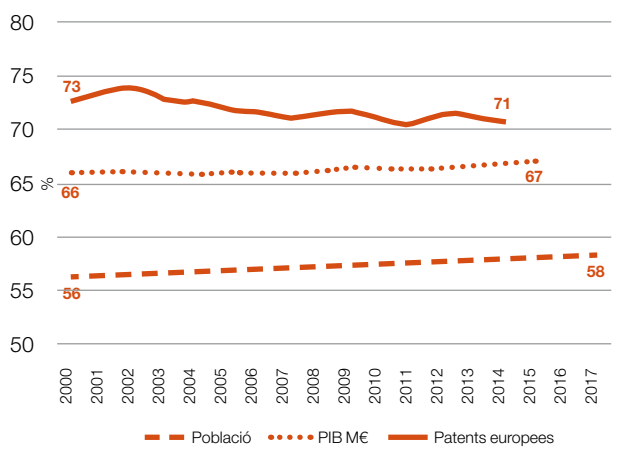
7 Patent applications have been assigned territorially based on the inventor's address (not the applicant's), as is customary in the bibliography on patents. This is due to the fact that it is considered to be the best approximate of the place where the invention is made. Therefore, the unit of analysis are applications of patents assigned territorially based inventor's address (and if there is more than one address, the allocation is fractional).

total of the EU-28 increased from 56% in 2000 to 58% in 2017 (see graph 1). In terms of GDP in millions of Euros, the weight of these regions over the total of the EU-28 also increased, going from 66% in 2000 to 67% in 2015, the last year for which there was data for all regions. In terms of innovation, measured in European patents by the inventor's address, the weight of metropolitan regions with respect to the total decreased, going from a weight of 73% in 2000 to 71% in 2014 (the last year for which data was available).

In summary, if only the period 2000-2014 is taken into account -for which data was available for all the variables- it can be seen that the population of the metropolitan regions has increased 1.6 percentage points, the GDP has grown – even with the deep economic crisis of 2008- 0.9 percentage points and patents have been reduced by 1.9 percentage points. It should also be noted that in the set of metropolitan regions there is a very significant concentration in the 25 most important metropolitan regions in terms of GDP (see map 1): these concentrate 31% of the total GDP of the EU-28 and the 32% of the patents but only 20% of the population (table 2), values that would indicate levels of productivity and intensity of knowledge far superior to those of the rest of European regions.

As can be seen in table 2, London and Paris are by far the regions with the highest GDP (838,000 and 667,000 million Euros

Graph 1. Weight on the EU-28 of the population, the GDP in millions of Euros and the European patents of the metropolitan regions, 2000-2017



Source: IERMB based on data from Eurostat and OECD, REGPAT database, March 2018.

respectively and a weight on the EU-28 higher than 4% each). Next, the regions of Madrid (203,000 million Euros and a weight of 1.4%) and Milan (193,000 million and 1.3% of weight) stand out. The region of Barcelona, with 151,000 million Euros, occupies the eighth position, just below Munich, Berlin and the Ruhr area.

In terms of population, London and Paris are also the most populated regions (more than 14 and 12 million people, respectively, and a weight on the EU-28 higher than 2%). Madrid also ranks third in terms of population, with more than 6 million people and a weight of 1.3%. In contrast, Barcelona occupies the fourth position with more than 5.4 million people.

As for patents, Paris is the region that concentrates the highest number, with 3,168 patents in 2014, 5.8% of EU-28 patents. The French region concentrates twice as many patents as the London region (1,374 patents and 2.5%), as well as the regions of Munich and Stuttgart (with more than 1,500 patents and 2.8% each). The regions of Milan, Barcelona and Madrid - in comparison - are below 500 patents and less than 1% of EU-28[8] patents.

Regarding the evolution of the weight of these metropolitan regions over the total of the EU-28, it is observed that the impact of the economic crisis has been especially noticeable in the GDP (see graph 2). Between 2000 and 2008 the weight on the EU-28 decreased and went from 30.1% to 29.6%. However, with the economic recovery its weight increased again fast to 30.7% in 2015.

Regarding the evolution of the population's weight, it should be noted that it has had a positive and sustained behaviour over time. They changed from representing 18.2% of the population of the EU-28 in 2000 to 19.6% in 2017 (see figure 3).

The evolution of the weight of the population on the EU-28 has been more positive than the weight of the GDP during the period 2000-2015, since the former has grown by 1.2 percentage points while the latter has increased by 0.5 percentage points. However, in the recent period of economic recovery (2009-2015) GDP has grown the most: while the weight of GDP over the EU-28 increased by 0.8 percentage points, the

8 The metropolitan area of Barcelona, here understood as the NUTS 3 of Barcelona, is the fourth region in terms of population, the eighth in terms of GDP but the 21th in terms of European patents in all metropolitan regions and NUTS 3 of the EU-28.

Table 2. GDP in millions of euros, population and European patents of the main metropolitan regions, in absolute value and in percentage on the EU-28, 2015, 2017 and 2014

				In% of the EU-28		
Metropolitan Region	GDP in millions of Euros (2015)	Population (2017))	European Patents (2014)	GDP in millions of Euros (2015)	Population (2017))	European Patents (2014)
London	838.330	14.187.146	1.374	5,7	2,8	2,5
Paris	667.641	12.193.865	3.168	4,5	2,4	5,8
Madrid	203.602	6.476.838	256	1,4	1,3	0,5
Milan	193.232	4.316.398	467	1,3	0,8	0,8
Munich	171.189	2.879.107	1.526	1,2	0,6	2,8
Berlin	166.494	5.207.915	906	1,1	1,0	1,6
The Ruhr area	157.900	5.118.681	997	1,1	1,0	1,8
Barcelona	151.145	5.474.482	415	1,0	1,1	0,8
Rome	150.315	4.353.738	139	1,0	0,9	0,3
Hamburg	148.190	3.282.164	728	1,0	0,6	1,3
Dublin	145.122	1.917.677	183	1,0	0,4	0,3
Stockholm	143.299	2.269.060	717	1,0	0,4	1,3
Stuttgart	141.355	2.757.930	1.519	1,0	0,5	2,8
Frankfurt	139.176	2.671.358	801	0,9	0,5	1,5
Amsterdam	138.704	2.729.421	265	0,9	0,5	0,5
Brussels	124.072	2.513.849	326	0,8	0,5	0,6
Copenhagen	118.839	2.811.186	375	0,8	0,5	0,7
Manchester	117.156	2.014.225	619	0,8	0,4	1,1
Marseille	108.720	3.287.460	218	0,7	0,6	0,4
Cologne	93.741	3.099.950	328	0,6	0,6	0,6
Athens	92.559	1.987.901	423	0,6	0,4	0,8
Düsseldorf	84.374	3.773.559	69	0,6	0,7	0,1
Helsinki	84.087	1.545.431	550	0,6	0,3	1,0
Lyon	81.766	1.638.293	704	0,6	0,3	1,3
Metropolitan regions (25)	79.486	1.860.112	398	0,5	0,4	0,7
Other metropolitan regions (242)	4.540.494	100.367.746	17.472	30,7	19,6	31,7
Other non-metropolitan regions	5.391.450	190.231.094	21.508	36,4	37,2	39,1
Total EU-28	4.865.500	220.923.831	16.070	32,9	43,2	29,2
Total UE-28	14.797.444	511.522.671	55.050	100,0	100,0	100,0

Source: IERMB based on data from Eurostat and OECD, REGPAT database, March **2018.**

weight of the population on the EU-28 increased only by 0.4 percentage points.

Finally, the weight of European patents in these 25 metropolitan regions decreased between 2000 and 2014, going from 35.3 to 31.7% (see graph 4). Nevertheless, in this case, it is interesting to note that their weight loss was distributed almost equally between the rest of the metropolitan regions and the non-metropolitan regions (in both cases they gained around 2 percentage points, with the difference that in one case there are 242 metropolitan areas and 380 NUTS 3 and in the other, 841 NUTS 3) (see figure 5).

European patents in Catalonia and Barcelona

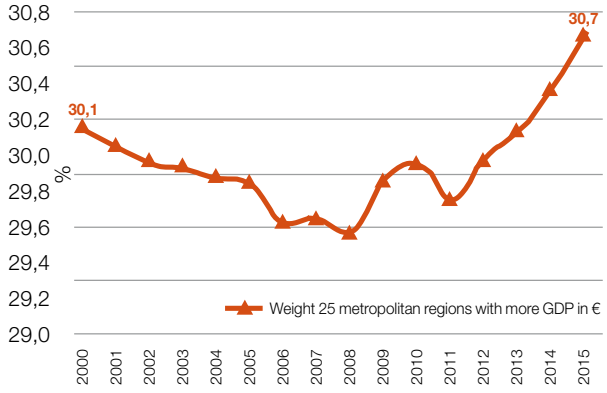
After seeing the high concentration of innovation in the main European metropolitan regions, the evolution for the period 2000-2015[9] of European patents in Catalonia is analyzed from the information provided by REGPAT[10] patents database prepared by the OECD.

During the period 2000-2015, a total of 19,670 applications of European patents were requested in Spain according to the in-

9 It should be taken into account that the innovative process is often the product of long periods (over a year). When it comes to innovation, the use of exclusively annual indicators can produce a distorted image by basically collecting innovation "registered" in a year, but not necessarily produced only in this year. For this reason, the methodological option is to analyze the flow of innovation indicators produced over a series of years.

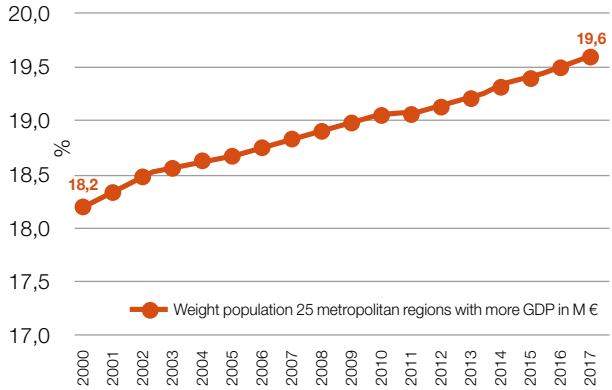
10 The OECD REGPAT database presents patents data that have been linked to regions according to the applicant's and inventor's address, although in this article only the inventor's address is used.

Graph 2. Weight on the EU-28 of the 25 metropolitan regions with more GDP in millions of Euros, 2000-2015



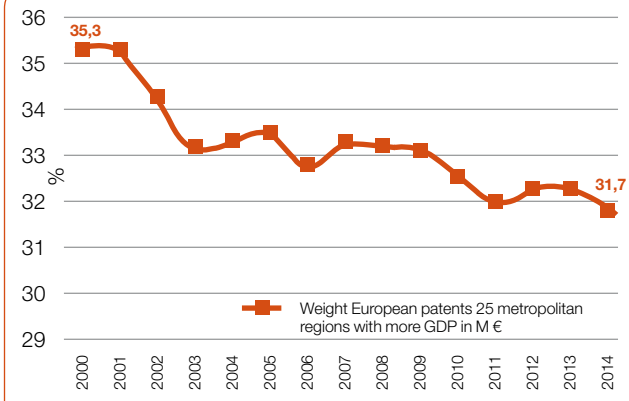
Source: IERMB based on Eurostat data

Graph 3. Weight on the EU-28 of the population of the 25 metropolitan regions with more GDP in millions of Euros, 2000-2017



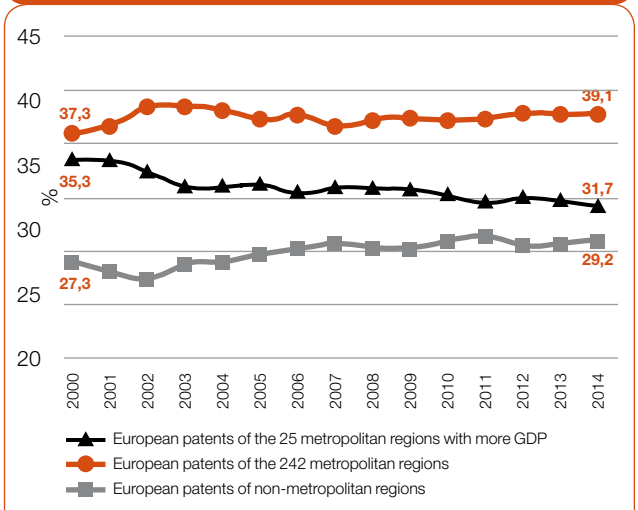
Source: IERMB based on Eurostat data.

Graph 4. Weight of patents on the EU-28 of the 25 metropolitan regions with the highest GDP, 2000-2014



Source: IERMB based on data from Eurostat and OECD, REGPAT database, March 2018.

Graph 5. Weight of European patents on the EU-28 of the 25 metropolitan regions with the highest GDP, of the 242 metropolitan regions and non-metropolitan regions, 2000-2014



Source: IERMB based on data from Eurostat and OECD, REGPAT database, March 2018.

Table 3. European patents by inventor's address in the Catalan provinces, Catalonia and Spain, 2000-2015

Year	Barcelona	Girona	Lleida	Tarragona	Catalonia	Spain
2000	227	21	6	26	281	743
2001	304	15	10	29	359	848
2002	310	20	8	31	369	936
2003	320	27	3	18	368	921
2004	362	18	15	13	408	1.000
2005	458	26	6	26	517	1.298
2006	466	34	10	25	534	1.399
2007	495	32	7	26	560	1.403
2008	443	23	10	21	498	1.374
2009	431	30	8	19	488	1.444
2010	467	32	5	16	520	1.645
2011	428	29	15	20	493	1.491
2012	469	25	11	18	523	1.565
2013	463	22	16	13	514	1.581
2014	415	20	12	17	464	1.362
2015	194	13	7	7	221	658
Total 2000-2015	**6.251**	**388**	**151**	**326**	**7.117**	**19.670**
In % on Catalonia	88	5	2	5	100	
In % on Spain	32	2	1	2	36	100

Source: IERMB based on data from Eurostat and OECD, REGPAT database, March 2018.

ventor's address (see table 3). 36% of these patent applications were requested from Catalonia (7,117 according to the inventor's address). Therefore, innovation has a prominent role in Catalonia with respect to the whole of the State. And within Catalonia, the province of Barcelona is where most of the patents were requested, since a total of 6,251 applications were registered according to the inventor's address. That is, it represents 88% of the patents of Catalonia.

Thus, based on this data, it can be seen that innovation in Catalonia is especially concentrated in the province of Barcelona. Regarding the rest of the Catalan provinces, Girona and Tarragona stand out -they registered more than 300 patents which represent 5% of patents in Catalonia- while Lleida is far below. Regarding the weight of the patents with respect to the total of Spain, the province of Barcelona represents 32% of the patents, while the rest of provinces represent 1-2%.

The year on year evolution of European patents in the province of Barcelona shows a growing trend until reaching a maximum in 2007 (almost 500 patents). The economic crisis that began in 2008 reveals its effects with a fall in the number of patent applications, especially during the years 2009 and 2011. As of 2012, the fall in the number of patent applications decreased and in the following years it began to slightly increase, although it has not yet recovered to the levels prior to the economic crisis.

Patents and technological specialization in Barcelona

As it has been proved in the previous section, the majority of European patents are concentrated in the province of Barcelona. The next step is to analyze inside the province of Barcelona and its technological specialization. Wanting to analyze spatially detailed information (the province of Barcelona) makes it necessary to work with the information of the patent registries of the Worldwide Patent Statistical Database, also known as PATSTAT.[11]

During the period 2005-2016, a total of 15,326 patents according to the inventor's address were requested in Spain (see table

11 The different moments of update of the data in both bases causes small differences in the number of patents.

4). More than a third of these patents came from Catalonia (5,345 according to the inventor's address). Catalonia, therefore, has a prominent role in innovation in the whole State. Of all these patents, the vast majority were concentrated in the province of Barcelona: 4,746 patents, a figure that represents 89% of all patents in Catalonia in this period.

Most of the patents in Catalonia were registered in the Metropolitan Region of Barcelona (RMB for its Catalan acronym).[12] A total of 4,499 were registered there which accounts for 84% of all the patents in Catalonia. On the other hand, in the integrated municipalities of the Metropolitan Area of Barcelona (AMB)[13] a total of 3,222 patent applications were registered according to the inventor's address (60% of the total of Catalonia) and in the municipality of Barcelona 1,717 patents were requested (32% of the total of Catalonia). Based on these data, it can be seen that innovation is concentrated in the centre of the metropolis.

As regards to the weight of patents with respect to the total in Spain, patents requested in the province of Barcelona represent 31% of the patents requested in all of the State. The patents requested in the RMB represent 29% -only 6 percentage points less than the whole of Catalonia. This small difference proves, again, the relevance of the RMB in terms of innovation with respect to the whole of Catalonia and Spain.

At the same time, the patents requested by inventors from the AMB represent 21% of the requests in all the State. That is, between a fifth and a quarter of the innovation produced in Spain is concentrated in the AMB municipalities, mainly in the municipality of Barcelona, where 11% of the patents were registered.

Maps 2 to 6 below present the geographical distribution of European patents applications by technological sector (electricity-electronics, instruments, chemistry, mechanical engineering and other sectors) during the period 2005-2016. Geographical coordinates have been assigned to each patent following the inventor's postal address.

Generally, in terms of European patents innovations are registered in two large concentrations, one centred in Barcelona city and the other following the B-30 motorway. The concentrations around large cities with an old industrialization (such as Sabadell and Terrassa) and the municipalities that concentrate industrial activity in sectors such as the automotive (Martorell and Abrera) and chemistry and pharmacy (such as Sant Cugat del Vallès and Granollers, among others) stand out.

In order to quantitatively analyze the technological pattern of the innovation made in Barcelona, it is possible to analyze in more detail up to 35 technological fields grouped in the five techno-

12 RMB consist of the 164 municipalities corresponding to the counties of Alt Penedès, Baix Llobregat, Barcelonès, Garraf, Maresme, Vallès Occidental and Vallès Oriental. 91% of the entire population of the province resides in this area (2017).

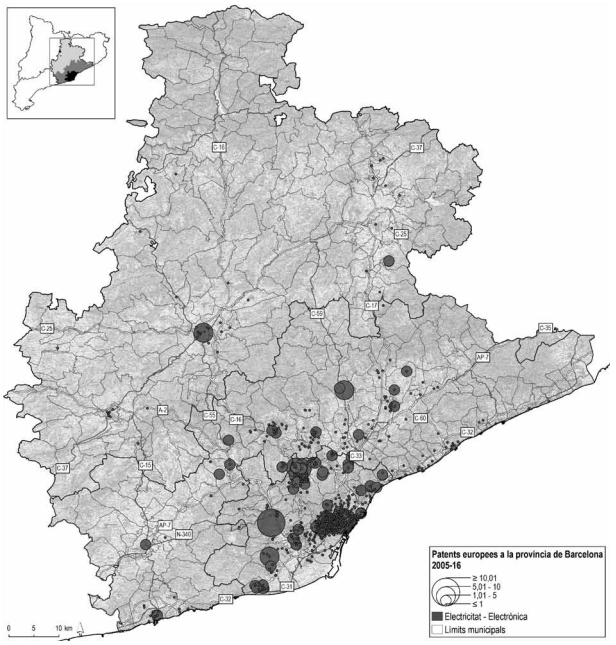
13 Although AMB corresponds to the acronym of the public institution Metropolitan Area of Barcelona, in this paper we use AMB to refer to the corresponding territory, consisting of Barcelona and the other 35 surrounding municipalities. 58% of the population of the province resides (2017) in this area.

Table 4. European patents applications in different fields, by inventor's address, total and in percentage on Spain and Catalonia, 2005-2016

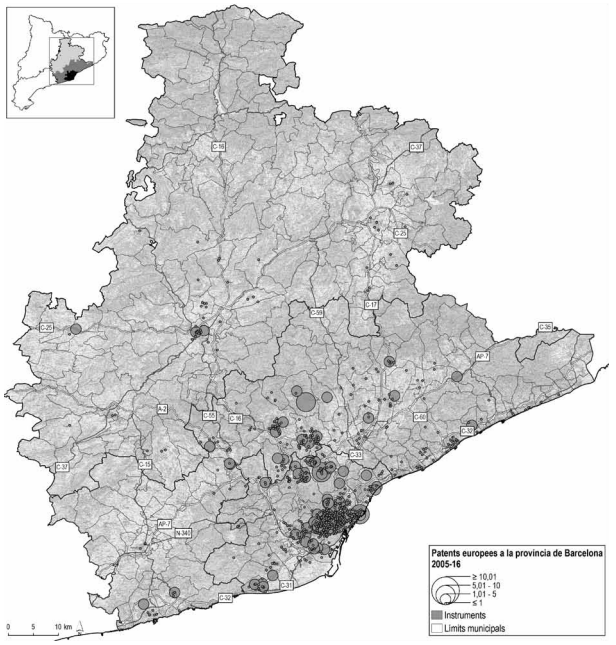
	Patents	in% on Catalonia	in% on Spain
Barcelona	1.717	32	11
Rest of AMB	1.505	28	10
AMB (36 municipalities)	3.222	60	21
RMB (164 municipalities)	4.499	84	29
Province of Barcelona	4.746	89	31
Rest of Catalonia	599	11	4
Catalonia Spain	5.345	100	35
Spain	**15.326**	**404**	**100**

Font: IERMB a partir de dades de la Worldwide Patent Statistical Database de l'OEP, primavera del 2017.

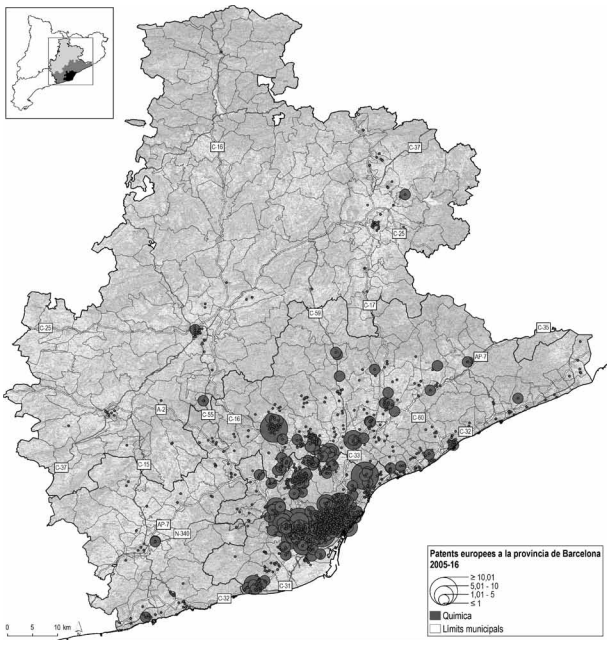
Map 2. Patent applications in the province of Barcelona, by electrical-electronics sector, by inventor's address, 2005-2016



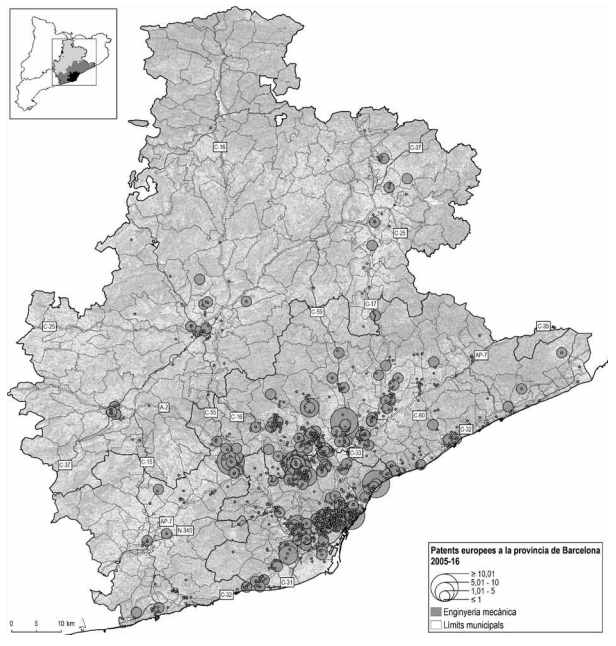
Map 3. Patent applications in the province of Barcelona, by instruments sector, by inventor's address, 2005-2016



Map 4. Patent applications in the province of Barcelona, by chemical sector, by inventor's address, 2005-2016

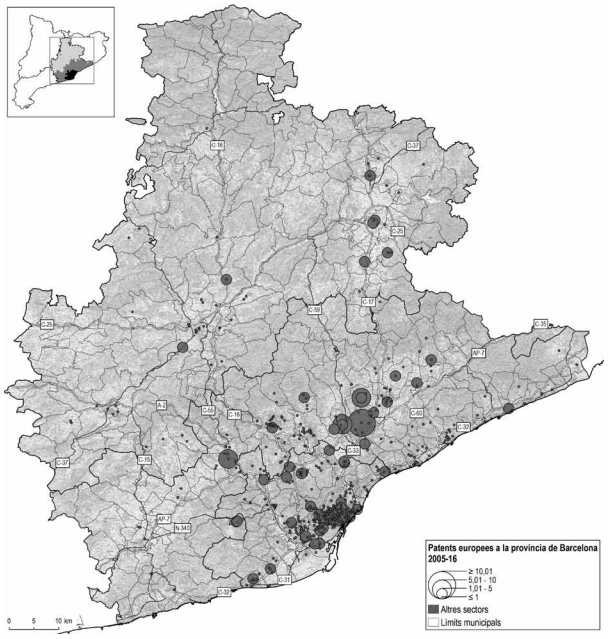


Map 5. Patent applications in the province of Barcelona, by mechanical engineering sector, by inventor's address, 2005-2016



Source: IERMB based on data from the Worldwide Patent Statistical Database of the EPO, spring 2017.

Map 6. Patent applications in the province of Barcelona, for other sectors, by inventor's address, 2005-2016



Source: IERMB based on data from the Worldwide Patent Statistical Database of the EPO, spring 2017

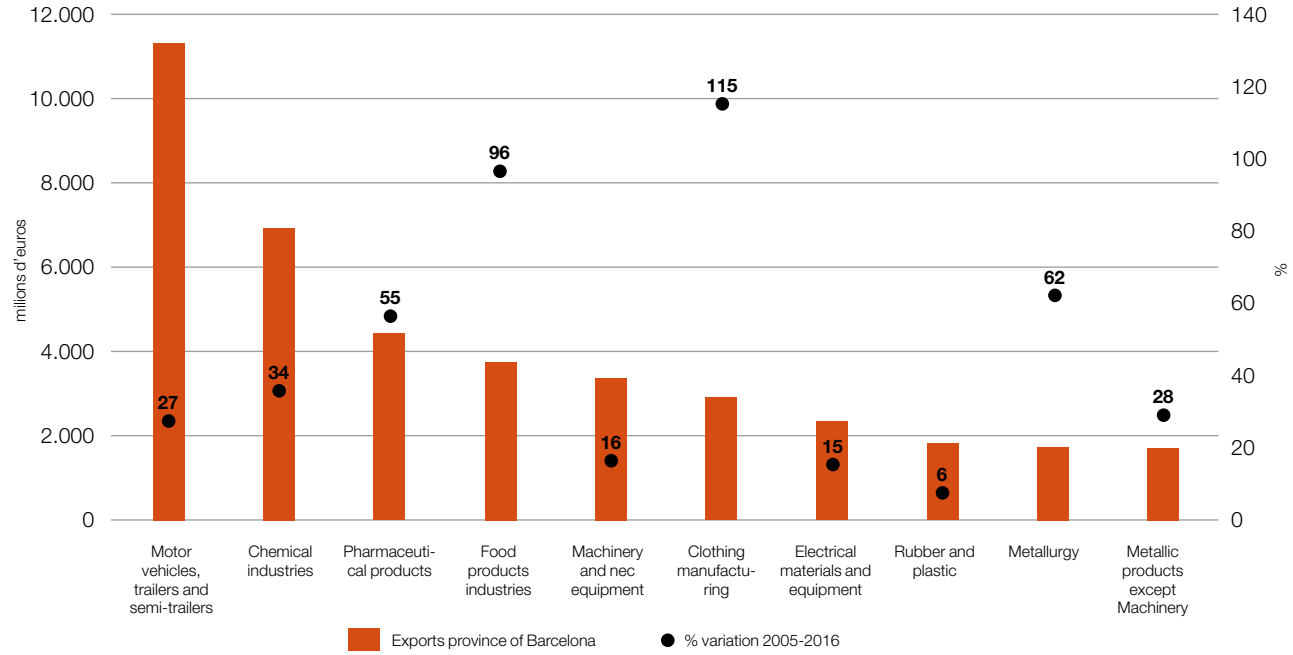
logical sectors represented by the previous maps[14] (see table 5).

It is clear that most innovations in the form of patents belong to the technological sector of chemistry, with more than 1,700 patents in the period 2005-2016. This represents more than a third of all patents (38%). The second sector in importance is mechanical engineering, with 1,312 patents and 28% of all the patents. The third sector is electrical-electronics engineering, with 642 patents and 14% of the total of patents. The fourth technological sector is technology of instruments, which has 523 patents and 11% of the total. Finally, the remaining technologies are grouped in the other sectors group, with 476 patents and 10% of the total number of patents.

If analyzed in more detail, at a technological field level, it should be noted that the most important field is pharmaceutical products with 15%, followed by organic processed products, with 8%

14 The document prepared by the IERMB, Mapa de les activitats innovadores a l'Àrea Metropolitana de Barcelona (Galletto et al., 2015), outlines the methodology used to classify technologies protected by patents in five sectors and 35 technological fields.

Graph 6.Main export sectors in the province of Barcelona of 2016 and variation between 2005 and 2016 (in constant terms)



Source: IERMB from the AEAT.

Table 5. European patents applications in the province of Barcelona according to the technological profile and inventor's address, total and percentage of the total of the province of Barcelona, 2005-2016

Camp tecnològic	Província de Barcelona	% Província de Barcelona
1.00 Electrical-electronics	**642**	**13,5**
1.01 Electronic devices, electronic engineering, electrical engineering	230	4,8
.02 Audiovisual technology	53	1,1
1.03 Telecommunications	93	2,0
1.04 Digital communication	62	1,3
1.05 Basic communication process	23	0,5
1.06 Computer technology	129	2,7
1.07 Management methods through IT	24	0,5
1.08 Semiconductors	28	0,6
2.00 Instruments	**523**	**11,0**
2.09 Optics	39	0,8
2.10 Measurement	91	1,9
2.11 Analysis of biological materials	73	1,5
2.12 Control 2.13 Medical technology	73	1,5
3.00 Chemistry	246	5,2
3.14 Processed organic products	**1.792**	**37,8**
3.15 Biotechnology	403	8,5
3.16 Pharmaceutical products		
3.17 Macromolecular chemistry, polymers	721	15,2
3.18 Food chemistry	53	1,1
3.19 Materials chemistry	71	1,5
3.20 Materials, metallurgy	116	2,4
3.21 Surface technology, coatings	41	0,9
3.22 Technology of microstructures, nanotechnology	47	1,0
3.23 Chemical engineering	4	0,1
3.24 Environmental technology	69	1,4
4.00 Mechanical engineering	39	0,8
4.25 Handling	**1.312**	**27,7**
4.26 Machine tools	251	5,3
4.27 Motors, pumps, turbines	67	1,4
4.28 Textile and paper machinery	166	3,5
4.29 Other special machinery	158	3,3
4.30 Thermal processes and devices	165	3,5
4.31 Mechanical components	63	1,3
4.32 Transportation	141	3,0
5.00 Other sectors	301	6,3
5.33 Furniture, games	**476**	**10,0**
5.34 Other consumer products	156	3,3
5.35 Civil engineering	88	1,8
5.35 Enginyeria civil	232	4,9
Total	**4.744**	**100,0**

Source: IERMB based on data from the Worldwide Patent Statistical Database of the EPO, spring 2017.

of the total, both belonging to the chemical sector. On the other hand, the third and fourth fields correspond to mechanical engineering and are transport and handling, with 6% and 5%, respectively.

It should be noted that this pattern of technological specialization is significantly different from the one observed in all patents worldwide. Here, the most important sector is electrical and electronics engineering, followed by chemistry and mechanical engineering[15] in third place.

Export behaviour and innovation

Patents are aimed at legally protecting new technologies and products. At the same time, assuming the cost of registering a patent by the applicant is related to the expected profitability of the trading of the technologies and products it protects. In addition, the fact that European patents serve to search for protection in a very extensive geographical area, continental practically, implies that the reference market of the applicants is not only the closest but one of the most extensive, international, and that, therefore, they are interested in obtaining protection also in international markets. Thus, it is interesting to analyze what relationship is established between the main technological sectors by number of patents applications and the main export sectors, in this case the province of Barcelona.

Graph 6 shows which ones were the first export sectors in 2016 in the province of Barcelona[16] by total value of exports, in millions of Euros and the percentage variation with respect to the total value of exports in 2005.[17] Information on the sectors is presented in a two-digit aggregation level of the CNAE-09.

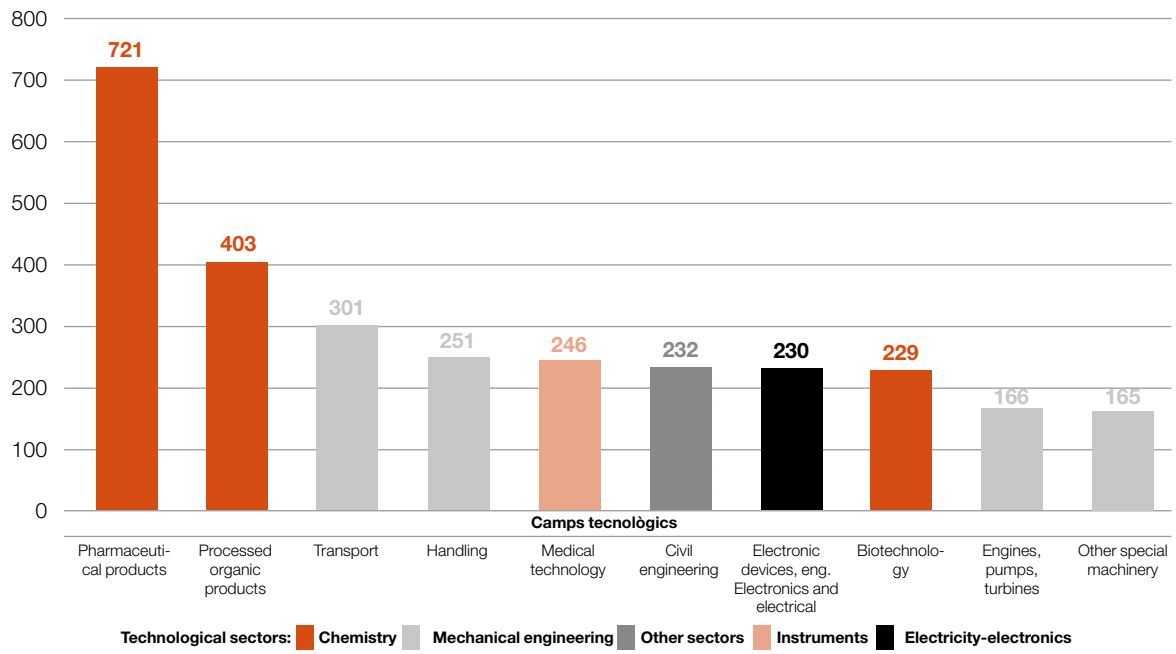
The main export sector by value of exports in 2016 was the sector of the manufacture of motor vehicles, trailers and semi trailers with more than 11,300 million Euros. Then, the chemical industry sector exported more than 6,800 million Euros.

15 See Galletto et al. (2015)

16 There is no data available for a level of disaggregation lower than that of the province which would allow us to calculate the aggregate for the territory of the AMB. The province of Barcelona is, therefore, the geographical area closest to the object of analysis of this study.

17 The comparison is made in constant terms.

Graph 7. Main sectors and technological fields by number of patents by inventor. Province of Barcelona, 2005-2016 2005-2016



Source: IERMB based on data from the Worldwide Patent Statistical Database of the EPO, spring 2017.

The manufacture of pharmaceutical products -another sector related to the chemical industry- exported almost 4,400 million Euros. Following them by a certain distance, the sectors of the manufacture of food products, machinery and equipment and clothing manufacture exported approximately 3,000 million Euros, respectively. Exports from the rest of the main sectors (manufacture of materials and electrical equipment, manufacture of rubber and plastic products, metallurgy, and manufacture of metallic products) go from 1,500 to 2,300 million Euros.

Graph 6 shows, in addition, the percentage variation of the value of exports between 2005 and 2016. The sector where exports increased the most in relative terms of this selection of export sectors was that of clothing manufacturing (115 %), followed by the food industry (96%). The metallurgy sector (62%) and pharmaceutical products (55%) also increased notably. The chemical industry and manufacture of motor vehicles, trailers and semi-trailers sector increased exports by around 30%, although it should be noted that since these are the sectors with the most exports, this variation represents a considerable increase in absolute values. The rest of sectors increased exports between 5 and 15% approximately.

Graph 7 shows the main sectors and technological fields by number of patents in the province of Barcelona, according to the inventor's address, during the period 2005-2016. The graph distinguishes between sectors and technological fields. As can be seen, the main sector is the chemical sector, where the technological fields of pharmaceutical products, processed organic products and biotechnology stand out (with 721, 403 and 229 patents, respectively). Next, in second place the mechanical engineering sector stands out, with the fields of transport, handling, engines, pumps, turbines and other special machinery (301, 251, 166 and 165 patents, respectively). The sector other sectors is in third position and stands out for civil engineering (232 patents). Finally, among the main technological fields of the province of Barcelona by number of patents only two fields belonging to the sectors of instruments and electrical-electronics stand out: medical technology (246 patents) and electronic devices, electronic and electrical engineering (230 patents).

At this point, it is interesting to make a brief consideration on the relationship between the economic sectors that have shown better export performance and the main technological fields by number of European patents.[18] First of all, we must highlight the chemical and pharmaceutical sectors, which rank in the top positions both in terms of exports and in the number of patent requests, in the fields of pharmaceutical products, processed organic products, biotechnology and medical technology. In addition, in terms of exports, the evolution during the period 2005-2016 has been positive, with a growth of more than 30% in the chemical industries and more than 50% for pharmaceutical products. Secondly, vehicle manufacturing stands out. Although it is not the most dynamic export sector, it leads exports (in terms of value) and generates a considerable number of patent applications related to the mechanical engineering sector, as in the field of transport and engines, pumps, turbines. Third, the sector that has increased most in exports (considering only the ten most important sectors quantitatively), is the sector of clothing manufacturing. This sector does not have an obvious equivalent in terms of the technology sector, although it is likely to benefit from innovations in the mechanical engineering sector, among others.[19]

Naturally, this consideration has to take into account the fact that the relationship between the economic sector and technological sector is not perfect, in the sense that, for example, a patent in the technological sector of mechanical engineering can be used by the economic sector of chemistry, or a patent of the electrical-electronic sector can be used by the vehicle manufacturing sector. In any case, it does detect a clear coincidence between the main export sectors in the province of Barcelona, chemistry and vehicle manufacturing, and chemical and mechanical engineering patents, highlighting, therefore, technological innovation. Consequently, research and development efforts are a source of international competitiveness for companies located in the province of Barcelona and, by extension, the RMB and the AMB.

Conclusions

The paper studies the relationship between innovation, city and

18 On the role of the industry in ending the crisis of the Catalan economy, see Revista Econòmica de Catalunya, n. 62, monograph " La Catalunya futura: bases per a un nou model econòmic ", October 2010.

19 In any case, clothing manufacturing is a sector in which competitiveness is determined in an important way by factors other than technology, as design and flexibility to adapt to the changing demand of the market. These can be more efficiently protected by other intellectual property instruments which are not patents.

competitiveness at the scale of European metropolitan regions, based on the exploitation of recent economic and patent databases. It is concluded that the European metropolises have a central role in the field of innovation. Among these metropolitan regions, the metropolis of Barcelona stands out as a leader in terms of population and GDP; on the other hand, in terms of innovation, Barcelona is far from the top positions.

The study detects a growing concentration of economic activity and population in metropolitan regions with higher GDP levels. Regarding innovation, what stands out is the very high level of concentration in these regions (71%), although this high concentration tends to be reduced.

It also highlights the quantitative identification of the metropolis of Barcelona within the 25 richest European metropolitan regions. Barcelona, additionally, constitutes the fourth metropolis in terms of the population of all the metropolises studied. It appears as the central innovation node of the Catalan and Spanish economy as a whole.

On the other hand, a relationship between technological innovation and international competitiveness is detected. The innovative capacity that the Catalan economy has shown in recent decades coincides with a great leap in exports.

Finally, a conclusion is drawn from the paper regarding the design of a new economic policy. The need to boost the innovative capacity of the metropolis of Barcelona to place it also in this field at the high levels it has achieved in terms of population and production among all the European metropolises. We must move from the Catalan and Spanish leadership in innovative capacity to a new European leadership. ■

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