The Catalan innovation and science system: reality and potential

Interview with Luca de Meo, Chairman of the Executive Committee of SEAT

City and innovation. Space of knowledge and creation

SUMMARY

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CITY AND INNOVATION. SPACE OF KNOWLEDGE AND CREATION

INTRODUCTION
CITY AND INNOVATION. SPACE OF KNOWLEDGE AND CREATION

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The Revista Econòmica de Catalunya offers the reader a central *Dossier* dedicated to "City and innovation. Space of knowledge and creation." Nowadays, the city is a topic of analysis that goes beyond the disciplinary limits of an urban economics. In a 21st century economy, urban space is an outstanding topic of a new economic paradigm that affects the core of the system, the dynamics of innovation. In this dossier we intend to bring to the economic and territorial debate some elements that we hope will be useful to activate a reflection on the role of cities (of metropolis) in the new knowledge economy, in the new environments of creativity.

According to Kuhn, every new paradigm needs to identify new "relevant problems". And the relationship between city and innovation is one of the central issues of current economic analysis (also of political and social concerns). We need to make our way through difficult and often rarely analyzed territories. This is an issue that attracts controversy. Edward Glaeser, in his work The Triumph of the City (2011), shows the relationship between industrial and urban crisis, and points out the propelling role of urbanism in a new pattern of sustainable economic growth, and the importance of the compact city to guarantee sustainability. In contrast, Richard Florida, in his recent work on The New Urban Crisis (2017), emphasizes the aggravation of urban inequality (and the increase of suburban poverty). But both authors agree that cities and metropolitan areas must be platforms to activate innovation. And that this is an adequate path for economic growth.

The Milanese economist Roberto Camagni has recently highlighted that there is a process of convergence between different schools of economic analysis that points towards the need to address innovation from an urban or metropolitan perspective. Convergence between the Neo-Marshallian Industrial District school, with the outstanding figure of Giacomo Becattini (1977 and 2015), and the European school of *les milieux* (Groupe de Recherche Européen sur les Milieux innovateurs). Camagni (2016) proposes adjusting the new innovation policies on creative bases. The external Marshallian economies are appropriate to analyze both the economy of specialized industrial cities and those based on the knowledge economy. Fortunately, we now have typologies of activities and statistical sources to address part of these issues.

We would also like to highlight the opportunity to study these issues in a comparative perspective. In this sense, the Catalan economy presents a singularity: it has a fundamental urban asset with the metropolis of Barcelona. In the European context, the metropolis of Barcelona constitutes the central nucleus of a large European mega-region where cities as important as Lyon and Valencia act as a network. Apart from the metropolitan network, this region also includes Girona, Reus-Tarragona, Lleida and Manresa.

Therefore we should bear in mind the relevance of the topic under study when designing new urban policies. One of the consequences of the crisis triggered by the United States since 2007 is the intensification of inequality in the distribution of income both on an intra-urban and inter-urban scale. The OECD and the United Nations (UN-Habitat), among other intergovernmental institutions, have highlighted the need to promote economic policies that allow facing this new urban crisis. The proposal that emerges is known as the urban "in-

clusive growth" model. This model proposes fighting against inequality not only with redistribution policies but also with pre-distribution policies. This pre-distribution aspect requires activating policies that allow generating economic growth and at the same time improve the personal distribution of income while promoting activities that are dense in knowledge. Those activities are dense in employment and intensively attract employment in other sectors.

Barcelona has been leader in designing and implementing urban strategies based on the knowledge economy, with the outstanding example of 22@Barcelona. Nevertheless, there is still great potential if it knows how to activate economic processes based on creativity and on a new impulse to the knowledge economy. Barcelona has to be aware of its pulling role on the whole territory of Catalonia towards this direction.

The *Dossier* "City and innovation. Space of knowledge and creation" has been focused on these bases and incorporates theoretical and statistical elements within the analysis, without pretending to exhaust the arguments. It contains nine documents, briefly outlined below.

The first is an interview with Luca de Meo, president of SEAT with some questions about SEAT's strategy regarding innovation, creativity and the knowledge economy. SEAT -the first industrial company in Catalonia by sales volume, added value and export capacity- is following a very interesting innovative path. Not many companies like SEAT have considered the new relationship between the new economic, technological and urban parameters and their business strategy. This is a story of success in an environment that changes as the environments involving the new urban reality do.

 The next block includes seven articles, both with theoretical and applied content. The first article deals with the relationship between universities and the city, and is by Montse Álvarez (CYD), Francesc Solé Parellada (UPC-CYD) and Martí Parellada (UB-CYD). It includes a detailed study of the role of universities in the science and technology system, and the ecosystem of the metropolitan agglomeration of Barcelona.

The second article studies the location patterns of innovative sectors at metropolitan scale. It is written by Josep-Maria Arauzo-Carod, Eva Coll Martínez and Carles Méndez-Ortega, of the Universitat Rovira i Virgili, and outlines how, to a large extent, innovative capacity can be explained by the external environment and that there is a tendency to clusterization in the central nuclei of the metropolitan areas.

The third article analyzes the relationship between innovation, city and competitiveness and is by Marc Fíguls (IERMB), Vittorio Galletto (IERMB) and Joan Trullén (UAB). It studies the concentration of population, GDP and innovation in European regions and also European patents in Catalonia and Barcelona and their relationship with export behaviour.

The fourth article of the Dossier addresses innovation from the perspective of Marshallian Industrial Districts, and is by Rafa Boix (UV) and Fabio Sforzi (UParma). They analyze innovation that is not generated in large companies and large cities, but in MIDs and local production systems. The district effect on innovation in the MIDs of Spain between 1991 and 2015 is also analyzed.

The fifth article, by Montserrat Pareja (UB), is about creativity and knowledge and the urban foundations for generating innovation, and exposes how creativity is transformed into innovation to the city, and innovative processes can be promoted from cities.

The sixth article is by Jordi Garcia Brustenga (UB), Xavier Ticó (PCiTALLeida) and Laura Capel (UAB). It studies the RIS3 and the new role of cities within the innovation system, and the case of INNO4AGRO and the specialization and territorial competitiveness project of Lleida (PECT as per its Catalan acronym). It also considers the extent to which specialization and territorial competitiveness projects are instruments of innovation within the framework of the European Smart Specialization Strategy.

Finally, this section finishes with an article that outlines the possibility of introducing a universal basic income at urban level as an element of new generation innovation policies. The paper is by Xavier Ferràs (ESADE), Boyd Cohen (EADA), Steffen Farny (AaltoUSB) and Rachida Justo (IE).

The third and last section of the Dossier includes the conclusions of the 8th thematic block of the Catalan Economy and Business Congress of Economy on "Science and innovation system: reality and potential". The block was chaired by Enric Banda. Xavier López was the vice president and Xavier Lesauvage, the rapporteur (April 2018).∎

BLOCK I

INTERVIEW WITH LUCA DE MEO, CEO OF SEAT

INTERVIEW

LUCA DE MEO,
PRESIDENT CEO OF SEAT

"COOPERATION IS KEY TO PROMOTE A EUROPEAN MODEL OF INNOVATION"

I n recent years, technological and organizational innovation and digitalization have transformed society and the economy as never before. At the same time there is an intensification of the demand for mobility, especially in large cities.

How does SEAT face this double challenge?
It's a fascinating challenge. The digital environment and the new era of connectivity open up a world of possibilities to redefine our product and our services. In our sector that's precisely what it is, going one step beyond manufacturing vehicles and starting to offer mobility services.

SEAT has become a holding organization. This allows us to be more agile at an organizational level and to move forward towards the mobility of the future. Connected and shared cars or apps that facilitate urban mobility are some of the answers we provide for this demand from the big cities.

SEAT is leader in Catalonia in R + D + I. Talking about the automotive industry, what was the role of technological
and organizational innovation in its evolution and its current state?
Without a doubt, a fundamental role. The automotive sector has undergone a transformation at all levels in the last decades. The effort in investment we've made to be at the forefront in the era of digitalization has turned SEAT into the Spanish manufacturing company that invests more in R + D. This makes us very proud and at the same time it implies an enormous responsibility because we have a commitment to continue generating value to society.

In the same way, organizationally. Being efficient at an industrial level has allowed us to design systems to be more flexible and more agile.

How does SEAT want to continue driving innovation and design?
Our DNA is made up of innovation and design. We allocate 10% of revenues to innovation and we have more than a thousand engineers and designers at the Martorell Technical Centre. But we do not want to stop there. The new market

requires us to be flexible and agile and that is why SEAT has created XMOBA, to identify, test, market and invest in new models focused on mobility.

It's the same with design. SEAT designs all vehicles in Barcelona, a city recognized worldwide in terms of creativity and design. Having the creative capacity in our own headquarters and in a unique centre in Southern Europe, and also working with entities such as Barcelona Design Centre or ELISAVA, allows us to en-sure a constant recruitment of talent, increasingly important in the corporate environment.

And what would you say is SEAT's role in the development of the Catalan economy in the next ten years? Is the Barcelona factor fundamental?
SEAT is a fundamental driver of the economy, employment and investment in Catalonia and will continue to be so. More than 15,000 people work for us and we currently represent 4.1% of the GDP of the Catalan territory, and our target is to keep this impact in the future.

Barcelona plays a key role. It is a pioneering city in terms of digitalization, design and creativity, for example. These values are directly linked to the SEAT brand, and having this environ-ment's talent offers us another lever to predict a future of growth.

Does SEAT support strengthening the clusters as a way of promoting the automotive sector? Since some time ago, the automotive cluster of Catalonia groups together companies from the industry -including small and medi-um-sized companies. Do you consider clusters to be a good tool?
The automotive sector in Catalonia is at a unique moment and these types of associations allow us to reinforce the competitive-ness of our industry and create a win-win relationship between companies with common or complementary interests.

According to the data of the Automotive Industry Cluster of Catalonia, the global turnover of the automotive sector will in-crease this year by 6% compared to 2017. This evolution would not be possible without the collaboration of the companies in the sector and in addition it allows us to continue at the forefront of innovation and adaptation to the fourth industrial revolution we are in.

> **"SEAT is a fundamental driver for the economy, employment and investment in Catalonia and will continue to be so"**

Recently, an open innovation platform called Start4Bbig has been formed by Aigüesuas de Barcelona, CaixaBank, Naturgy, SEAT and Telefónica. This platform looks for start-ups with disruptive solutions. What is the strategy and what role does SEAT have?
The creation of Start4Bbig responds to the need to look for start-ups with disruptive and innovative solutions through chal-lenges that the driving companies put forward. The key lies in the fact that it's the first time five major companies have worked together to promote innovation and give entrepreneurs the op-portunity to access the market in a more agile manner.

SEAT has opted for this formula as a way of incorporating talent. We attract the best talent and entrepreneurs have the opportu-nity to develop their ideas with large companies like us.

Since 2008, more than half of the world's population lives in urban areas of more than 300,000 inhabitants and it is expected that by 2040 all regions of the world will be mostly metropolitan. Thus, issues such as urban mobility will become key issues. In this sense, you have promoted the SEAT Metropolis:Lab Barcelona. What is exactly its goal?
Metropolis:Lab Barcelona was born with the aim of developing intelligent solutions that facilitate mobility in cities. This is the only digital lab of the Volkswagen Group outside German bor-ders -together with the one in San Francisco-, and bringing it to Barcelona was a great milestone for SEAT. It's located at Pier 01, a building where around a thousand people from more than a hundred companies and start-ups coexist daily. This allows us to generate and benefit from synergies so that we can be more disruptive.

In fact, the knowledge shared between XMOBA and Metropolis:Lab -the two SEAT companies dedicated to develop-ing mobility services- will soon emerge.

We are developing multiple projects related to urban mobility from here. One of the first ones is About It, an app that shows charging stations for electric vehicles, cycle parking or black spots with the highest concentration of accidents in the city of Barcelona.

SEAT has also created the CARNET hub (Cooperative Automotive Research Network) together with the Universitat Politècnica de Cataluña (UPC) and the Volkswagen Group. What is the status of this knowledge hub on urban mobility? Are you satisfied with the evolution of international networking?
The collaboration between the partners in CARNET is very positive. Our objective is to continue participating in the development of this large research and innovation hub focused on the automotive and urban mobility of the future in Barcelona.

The Autonomous Driving Challenge was one of the most outstanding projects carried out. It was a competition aimed at rewarding young talent responsible for developing the technology of the future. More than 50 students from seven Spanish universities worked for six months in the creation of a software that allowed autonomous navigation of scale cars along a limited route. It's a great example that shows the success of the collaboration between companies and universities, in this case with the UPC.

CARNET continues working on new interesting initiatives that contribute to improving mobility in the city, but it's still too early to give more details about future projects.

Do you think that digital hubs should be encouraged more from the Administration? Is there a lack of pro-activity by the public sector?
Each actor has its role in the digital development. Companies, Public administration, financial institutions and social agents have to work hand in hand as cooperation is the key to promoting a European model of innovation. This includes the creation of new collaborative environments, clusters or innovation hubs that compensate small and medium-sized companies for their

lack of dimension when facing challenges and addressing Industry 4.0.

Here in Europe, we must aspire to catch up with models such as the ones in Israel or the United States. Those models promote these formulas and have become major references in digitalisation. It is essential to have a policy that favours the development of leading sectors, competition and business growth.

Carrying on with the topic of mobility, new fuels such as liquefied or compressed natural gas are being called to replace diesel and gasoline? What is SEAT's differential strategy in the fight against climate change?
The energy transition we are experiencing is unprecedented in the history of the automotive sector. There have never been so many and at the same time so sustainable alternatives available to customers and, therefore, it is a unique moment and we need to make the most of it.

For the next ten or fifteen years we'll have a huge range of fuels such as gasoline, diesel, natural gas, biogas, electricity, plug in hybrids, and so on in the market. Nevertheless, we must not forget that, in the end, the client will decide which options have come to stay.

Throughout all this process, success will be achieved by those who know how to adapt to such a changing environment and to the new needs of the customers.

The sector is also characterised by the rise of new forms of use based on "sharing", such as car-sharing. How do you think the collaborative economy is affecting the automotive market?
Today mobility -and therefore the automotive sector- are fully linked to the concept of collaboration and sharing. The collaborative economy and the new forms of mobility -such as car-sharing- are a reality that responds to the needs of users and to the active search for alternatives and new models in cities, by companies and institutions.

At SEAT, for example, we have launched initiatives such as the purchase of the car-sharing company Respiro, the integration of car-sharing systems at Martorell's production facility or the development of apps such as Justmoove which integrate a set of services for booking and paying parking lots, tolls or supplies,

for example. In short, offering customers solutions to improve their daily mobility.

SEAT's process of internationalization is exemplary. It went from being a company focused on the Spanish internal market to exporting most of its production -particularly to the European Union. To what extent does this "new internal market" need to be expanded? What is SEAT's strategy for the southern shore of the Mediterranean? After the success of SEAT in Mexico, is Latin America within SEAT's horizon of as a place of reference?
Indeed, globalizing the brand beyond European borders is one of SEAT's priorities. This year sales have grown 26% and 28% in mature markets such as the United Kingdom or Germany respectively; but we want to go one step further. Currently we are present in more than 80 countries on five continents and we want to focus in areas such as North Africa. In fact, the Volkswagen Group has relied on SEAT to lead the strategy in North Africa after the success of the project started last year in Algeria.

Latin America is also part of this strategy and we are analyzing the possibilities of strengthening our presence in the countries where we already have a presence and studying the possibility of entering new markets. ■

BLOCK II

ARTICLES

UNIVERSITY
AND CITY.
THE ECOSYSTEM OF BARCELONA'S METROPOLITAN AGLOMERATION

Montserrat Álvarez
UB and Fundación CYD

Francesc Solé Parellada
UPC and Fundación CYD

Martí Parellada
UB, Institut d'Economia de Barcelona and Fundación CYD

I t is generally accepted that we have entered into a new industrial revolution. This new industrial revolution appears as an acceleration of the threefold science-technology-innovation, which has become increasingly evident in the last 20 years.

This revolution is characterized by the increase of stock in science, technology and structured innovation in the digital world. Like any other industrial revolution, value chains have been extended and widened and, in this particular revolution, a series of scientific / technological areas such as nanotechnologies, new materials, biotechnology, robotics, advanced manufacturing, etc. have taken part. These areas have substantially promoted or modified different sectors of economic activity. However, and we must insist on this, the cementing factor of everything has been digitalization. This includes branches such as big data and artificial intelligence (AI), Internet between people and the Internet of things, and a series of related discoveries and inventions -very often spectacular and revolutionary- that have increased the capacity to store, transfer and operate with information.

Needless to say, this process has been propelled by abundant investment in platforms and IT applications.

All these technology changes –from which we benefit with products, such as mobile phones or autonomous vehicles- are not neutral. Their consequences on the environment, on social relations of all kinds and, even, on the management of globality are proof of it. Humanity, as a spectator of change, has begun to speak about the sudden disappearance of professions, radical changes in the geographical distribution of jobs, imminent changes in training models and teaching (among these, university teaching) and notable turmoil in the positions of the different social status, not to mention the geopolitical conflicts resulting from the imbalances. The specific problems that affect us are often not evident enough but there are symptoms of change and possible conflicts. These include the decline of the middle class, the precariousness of employment and sudden and frequent social conflicts.

Change also has economic consequences or, to be more precise, notable changes in the economic organization. Technical bases of competitiveness are the first ones to change. It directly affects the productive system both on a company's individual scale and in the markets as a whole and also in the geographical distribution of wealth. It goes without saying that this technological change -as happened in previous ones- will change the relative position of countries. It will also change the relative position

of what we have so far called ecosystems or, more technically, functional urban areas (FUR). FURs are identifiable economic areas that somehow have a personality that can be recognized. FURs include movements of agents that affect each other substantively.

It can be said that a FUR is a system which has its own norms and culture, that is, a way of doing and progressing with its strengths and weaknesses among which we can also identify barriers to progress[1]. Consequently, a FUR can be studied academically as a whole. Hence, although this article talks about Barcelona and its area of influence, the data can be extended without substantial variations in its conclusions to the perimeter of Catalonia. The proof is that we could not affirm the same if we considered separate parts of the perimeter.

First and foremost it seems that in the current situation, that is, at the beginning of a new industrial revolution, the cultural characteristics of the FUR in terms of written and unwritten rules, valid or accepted by the agents, have an obvious interest, since technological and economic changes question the commonly accepted social balances.

The imbalance between the recipes that allowed social agreement and that, until the arrival of the current industrial revolution, were protected by progress -even being its foundation- and the demands of maintaining comparative competitiveness can only be appeased in a scenario of cultural change and economic growth. Economic growth that allows those FUR to be placed in the group of ecosystems that lead the change. Growth and cultural change are expected to change the productive model and replace the old recipes of the welfare state with new social agreements. If both transformations do not go together, the latter acts as a barrier to progress. In other words, either we participate in the change with all its consequences, adapting the production system and social recipes or creating new ones, or it is easy to be left behind in a situation full of contradictions, both economic and social, that is difficult to leave from.

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1 The topic of culture in countries or regions and cities as a barrier or as a base for progress has not become a structured branch of economic science, connected to the rest of its branches. Nevertheless there is evidence of the difficulty that certain geographical areas have to respond correctly to opportunities for progress. This does not mean that this topic has not been considered. Adam Smith himself makes it one of the axes of his text on the origin of The Wealth of Nations. Many other economists have used it as a resource when comparing systems.

1. A typology of ecosystems

In the analysis of the geographical distribution of wealth we use the classification and explanations of Enrico Moretti in his well-known book *The new geography of jobs*.[2] Moretti classifies the economic geography of the United States into three types of territories (cities / metropolitan areas, regions or FUR):

a. On the one hand, there are those that constitute the hubs of innovation, with a strong presence of highly qualified and creative workers and high-tech companies in the fields of advanced manufacturing, information technology, life sciences, robotics, new materials or nanotechnology (although innovation is obviously not limited to only a high-tech classification and any employment that generates new ideas, processes and products is also included). It must be said that the list of sectors enunciated is not casual and marks the trend of which are the areas of the productive system creators of added value and that grow the most. These territories are characterized by their high productivity and, consequently, by high salary level, as well as high number of patents per capita.

b. On the other hand, there would be the areas in decline, characterized by the strong past presence of traditional, intermediate or even advanced manufacturing industries, which globalization and technological change have relocated in areas with lower labour costs, such as (at first) China and other emerging countries. These territories have not been able to readjust; they are losing population and jobs and are located on the negative side in wages and productivity. This classification alerts us to the relative importance of industrialization "for the sake of it". Not all the industry is equally productive and we could almost classify it in relation to its ability to resist, the ability of retribution and the ability to be part of the value chains in the branches with the greatest added value and the greatest participation in the complexity of the system and also a higher demand for public services. You should cry for the right reasons.

c. Finally, the third type of territory would be the one that represents ecosystems -if we can properly use this qualifier- with a very low level of complexity and in subsistence economies, with low salaries and practically nonexistent advanced services. Often, when people talk about countries, they talk about failed states or not viable countries.

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2 E. Moretti (2012). *The new geography of jobs.* New York: First Mariner Books.

In the first group of ecosystems the presence of the cluster phenomenon is very high, especially in the periods of creation of the sectors and consolidation of the district. Innovation clusters are increasingly attracting more leading companies and skilled workers; therefore they increasingly distance themselves from the other two types of territories in terms of added value and complexity.

On the other hand, the differences between these three types of territories are not only economic but also cultural, social, political, educational and also in terms of health where, for example, in the third type of territory services are incomplete, deficient and hardly structured.

In the territories that constitute the first group, that is, the pulse of the knowledge economy, a very intense multiplier effect is registered:

● It is estimated that only 10% of workers are employed in innovative enterprises, but for every one employed in these enterprises five additional jobs are generated in the local service sector (where most of those employed actually perform their tasks, about two out of three). In contrast, traditional manufactures, the territories of the second type of classification, have a multiplier effect of 1.6, which is therefore considerably lower than the sector of innovative companies.

● Of these five, 40% are employed in the sector of qualified professionals (doctors, teachers, lawyers, architects, etc.) and 60% in the traditional service sector (waiters, salespeople, cleaners, drivers, etc.).

● The largest multiplier effect of the high-tech sector would derive, to a large extent, from the fact that those people employed in this sector receive higher wages, thanks to a higher productivity, and spend more on local services that, logically, are located nearby.

The areas that concentrate talent, the first group, are increasingly moving away from the rest due to the fact that they are attracting more and more technologically leading companies and highly qualified workers. They achieved more and more progress in their productivity, in a kind of virtuous circle that expands the geographical area and creates homogeneous regions with considerable population agglomerations.

> *Surrounding ourselves with creative and intelligent people increases our own creativity and intelligence, and this makes us more productive*

This is due to three forces of agglomeration which make that, even with higher labour and living costs, companies set up there, since productive and creativity gains more than compensate for them. These three forces are:

● the increasingly dense and stratified labour markets;

● the presence of specialized service providers and, therefore, more professionalized;

● and, most importantly, the existence of *knowledge spillovers* that reinforce external technological economies and help to create chains with most added value.

The presence in the territory of a large number of companies belonging to high technology sectors and workers with the knowledge and skills needed in these sectors makes it easier for companies to find the appropriate personnel, that is, the engineer, scientist or specialized worker, in short, the human resources that they need. Workers can find a job that adapts to their expectations and skills. In addition, the possibility of having information to guide more efficiently the choice of training, and, for universities and training centres, the capacity to transform their teaching.

Likewise, innovative hubs have at their disposal an ecosystem of highly specialized service providers, in what we have called support area, such as legal advisors, advertising, technical and management consultants, logistics and repair, laboratories, support in engineering tasks, etcetera, and also financing resources. The territories of the first group are the area where venture capital firms are concentrated, which not only provide entrepreneurs and start-ups with the initial resources they need, but also do extensive tasks of supervision and tutoring and also, and very importantly, they facilitate the creation of the value chain filling the gaps that are detected

and, consequently, the expansion of the scientific and technological stock and the expansion of the ecosystem.

Finally, knowledge spillovers refer to the fact that social, formal and informal interactions between workers with high human capital generate learning opportunities that improve innovation and productivity. In other words, surrounding ourselves with creative and intelligent people increases our own creativity and intelligence, and this makes us more productive.

Therefore, the forces of agglomeration explain the divergence between territories. Once an area attracts some innovative companies and workers its economy changes in a way that makes the location attractive for other companies and innovative workers in a self-sustaining type of balance. This means that once a cluster of innovation has been established, it is difficult to delocalize and that a region without an innovation hub will find it difficult to create it from scratch. On the other hand, the negative effects of these knowledge hubs would be the high costs of living, including accommodation, and gentrification.

However, the current innovative hubs do not have to last forever –a consideration that has been the error in the study and assessment of the industrial districts in some very specialized territories and traditional industries-. With the passage of time technologies at the border will become standards, and currently innovative products will be easy to produce all over the world, in a kind of creative destruction, in terms of Schumpeter. Hence the need for the current hubs to readapt and reinvent themselves to continue existing.[3]

This is a key element that must be taken into account in the case of Catalonia: it is not so much about fostering nostalgia or waiting for a hypothetical conventional reindustrialization characteristic of the second type of territory, according to the Moretti typology, but of laying the foundations of the ecosystem characteristic of the first group of territories.

The origin of the current clusters has to do, in a certain sense, with serendipity. Chance and elements linked to entrepreneurial culture are often substantial.[4]

2. The road to follow

The success on the road that a FUR has to travel to participate in the 4.0 revolution, as a protagonist or as a follower with aspirations to move to the first group has two fronts that have to be covered. These are the productive system and culture understood as socially correct and accepted behaviour.

In terms of the productive system, and all the support area that go with it, there is no other option but to join the game characterized by the combination of science, technology, innovation, entrepreneurship and money, with the willingness to participate as an agent of change. In the cultural and social sphere one must have the attitude and ability to adapt, with imaginative and agreed solutions, to culturally felt social needs and socially demanded, whether justified or not. The system of science and technology and, logically, also the university lies in these areas of change. The university, in its role of creator of scientific and technological stock and also, and no less important, of human capital adapted to the new economic and social needs, becomes, as it has already been in other similar circumstances, a substantial agent of change.

The specific elements that will lead us to follow the right path are located in the field of foresight and, therefore, of the crystal ball. In other words, there is no roadmap in which all the steps to follow are written down, but there are many clues to what should be done and what should not be done and there are also examples of ways to move forward and some shortcuts to follow.

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3 Silicon Valley is an example. In the 90s, Silicon Valley was one of the pioneers in the hardware industry, then it re-adapted to software and, currently, to new technologies around the Internet, digital entertainment, biotechnology or net technologies. Detroit, which could be considered the equivalent of Silicon Valley in the 1950s, on the other hand, could not or knew not how to successfully re-orientate its ecosystem to new sectors from the automotive industry.

4 The case of Seattle is an example. The key to its rise to a hub of innovation comes largely from the decision of the creators of Microsoft (Bill Gates and Paul Allen) to move the company at the start from Albuquerque, where it was set up, to Seattle, the hometown of both. The presence of what was to become a giant of computer science triggered the creation of a high-tech cluster in the area that was used to attract other entrepreneurs and innovative companies, such as Jeff Bezos's Amazon. The origin of Silicon Valley, on the other hand, has to do with the arrival in the area of William Shockley, inventor of the transistor, whose disciples created the first integrated circuit in Fairchald Semiconductors, from which numerous spin-offs emerged as Intel or AMD, and gave the starting pistol to the most important innovation cluster in the world, where Apple, Facebook and Google are now installed. Shockley was connected to Stanford University.

The best-known prospecting method consists of three stages. First, it is a question of studying what happened in the past; second, of analyzing the relevant symptoms that we observe in the present and what solutions we see that are most effective in facing the imminent challenges; and third, of trying to add a point of imagination to all of this by constructing more or less plausible future scenarios.

In short, you do not have to dig too deep to find the right way forward. First of all, it is a question of signing up for the race with pleasure. A race that we will have to do anyway and, therefore, we'd better start it in good conditions. In this race, the winner is the one who innovates the most and does it with the most added value. The rules of the game reward those who best manage science, technology, human capital, and entrepreneurial capacity, the efficient organisation of the ecosystem and also the level of efficiency and the cost of the support space with the administration at the forefront. Those who play must be careful that no one is left outside socially and that the ecosystem has the capacity to rectify whenever appropriate. Most of the decisions, if the appropriate culture is given, are made by the ecosystem, but the science and technology system and the support space that depend on the administration must be observed and fed so that they advance in parallel and so that they push instead of being a hindrance.

All in all, it seems that what is needed is:
a. Provide the country with the capacity to contribute to the scientific and technological stock in a substantive way and through a structured and powerful science and technology system and, above all, focused. This system must have an entrepreneurial character and a final focus on relevance and also on demand. This feature is not added but must be consubstantial. In other words, the system has to be porous with the other agents of the ecosystem and it has to live comfortably in an otherwise inevitable state of global competition.

b. The system must have a human capital that naturally combines expertise and knowledge with skills and attitudes and with a high component of STEM (acronym for science, technology, engineering and mathematics). In other words, we must have a first level educational system, committed to the ecosystem and with the capacity to adapt, and therefore, porous.

c. A new social agreement that makes it possible and in which the whole population is comfortable.

d. An entrepreneurial productive system.

e. An effective administration, both in terms of the regulation of the productive system and in relation to its social responsibilities and, in addition, and very importantly, flexible and with a cost proportional to its effectiveness. Finally, and very importantly, with a culture focused on what it should and supported by democratic and civic values.

If this is the situation, each one, from their own position, will know what they need to forgo and the demands that have to be faced. In any case, the object of this article focuses on the first and the second point.

3. The role of universities and the structured science-technology system

The role of universities in local development is complex. Universities and structured research, that of groups, institutes, foundations of scientific purpose, etc., carry out, substantially, three tasks: contribute to increase the scientific and technological stock; build human capital in all directions, both knowledge and values and skills and abilities, and, finally, also transfer knowledge and contribute to innovation through the valuation by patents, spin-offs and science and technology parks. These tasks are by definition part of the foundations of change. For a country that wants to be at the forefront, having a university and an integrated quality research system is not a luxury, but a condition of progress. Kevin Kelly tells us in his book *New rules for the new economy*[5] that in the times in which we live *"wealth is not gained by perfecting the known, but by imperfectly seizing the unknown"* and this is precisely universities' forte.

Moretti argues that the birth of Silicon Valley was not due as much to the university as to the pioneers in high technology. If they had settled in any other location with another powerful research university, Silicon Valley would have emerged there, because the presence of the university is necessary but not enough. No matter how good universities and research systems are, the virtue of entrepreneurship is necessary if their contribution is to be fruitful. It is necessary for the research groups to be entrepreneurs and, above all, the presence of leaders (academic stars) is essential, with the capacity to investigate, patent and create companies and ensure that they survive and thrive. The

5   K. Kelly (1999). *New rules for the new economy: ten radical strategies for a connected world.* Nova York: Penguin.

> *Having a university and an integrated quality research system is not a luxury, but a condition of progress*

presence of academic stars in the right fields and their attraction effect was the key for the biotechnology industry in the United States to concentrate in the Boston-Cambridge metropolitan area (Harvard, MIT), San Francisco Bay (Stanford, Berkeley, University of California-San Francisco) and San Diego (University of California-San Diego). There are two reasons for the power of these stars: scientists and researchers from private start-ups need to have labs physically close to academic frontier research to capture the knowledge spillovers that are derived from elite academic researchers -hence the error of distancing scientific parks and university innovation from the universities and of not promoting mobility between the research and the productive system- and, on the other hand, academic stars are often personally involved in the task of entrepreneurship, with the creation of leading private start-ups. Nevertheless, the presence of these stars in certain universities and not in others was also random, a kind of serendipity.

In addition, the presence of universities in a city increases the offer of higher graduates. The percentage of highly qualified workers is key to an innovative hub, although, on the other hand, these workers tend to be very mobile and if the territory does not offer opportunities they often move their contribution to the FUR that offer them higher salaries and, especially, more encouraging projects.

In other words, the presence of universities and structured research, even if they are prestigious, does not guarantee economic success or development; they are important but, as said, not enough by themselves to form a self-sustaining cluster.

Universities and research systems are more effective, in fact, when they are part of a broader innovative ecosystem, together with a dense market of highly qualified workers and specialized service providers. That is, when a cluster has been established, universities have a key role in promoting its growth, often becoming a key player in the ecosystem that supports the innovative

hub and makes it successful[6], creating companies as a result of the academic research, in the form of patents, spin-offs, start-ups related to graduates and personnel of the faculties and generating knowledge spillovers that encourage the local innovative sector.

To foster development, there are few strategies alternative to boosting the system and lowering the barriers. The path that an ecosystem that effectively manages the threefold science-technology-innovation has to travel is not easy to boost through direct industrial policy actions, so we must expect the same ecosystem to evolve on its own, supporting its foundations and reducing the barriers.[7]

Consequently, we must conclude that it is necessary to preserve and promote the part of the support space represented by universities and the research system and to do so in a targeted manner, that is, in the direction of establishing the culture of porosity and mobility in relation to the social and productive system and to promote the culture of innovation and entrepreneurship in both directions.

Therefore, in our case it is whether the university and research system of Catalonia is prepared to continue supporting economic and social development in relation to the challenges of

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6   It should be taken into account, in this context, that the functioning of universities in the United States, even public, is quite different from the Spanish ones, as outlined in Vilalta (2018). "The contribution of universities to economic and social development. Reflections and experiences from California and Catalonia ", the CYD Report 2017. Barcelona: Fundació CYD. Thus, they are more autonomous, law regulations of the system are light and focus on accountability; the selection of teaching staff is a key element; the role of transferring technology and knowledge to society and the productive system is a nuclear activity and there is a wide range of institutions and mechanisms that foster innovation.

7   One of the few cases where this strategy worked was Taiwan, where Chinese scientists from the United States were repatriated and opted to establish a public R & D cluster that became sufficiently dense to support private companies, although it is also true that it was tried with several sectors and only was successful in the semiconductors. In this context, suburban innovation districts, such as 22 @ Barcelona, could be included, an example that is inserted into a broader framework of cities, as shown by Katz and Wagner (2014). *The rise of innovation districts. A new geography of innovation in America.* Metropolitan Policy Program at Brookings.

the industrial revolution 4.0. Hence, we need to make a precise and focused diagnosis and to have the strategy and resources to strengthen it in the right direction.

4. Barcelona's ecosystem

As said before, the future in the short and medium term will be marked by the digital economy and industry 4.0. The digital economy is the result of the disruptive capacity that the use of information and communication technologies (ICT) is producing for all sectors of the economy and for all social and personal activities.[8] The fourth industrial revolution (industry 4.0) has to do with the use of cyberphysics systems, autonomous robots, artificial intelligence, the Internet of things, cybersecurity, new materials and nanotechnology, 3D printing, cloud computing or big data. Industry 4.0 is also embedded in a fully digitized ecosystem that would include intelligent mobility, connected vehicle and autonomous driving, smart cities, smart electrical networks or e-commerce, as well as other concepts such as blockchain or sophisticated video games of virtual or augmented reality.[9] In this context it is clear, then, that the ICT sector is key.

In this sense, the ICT sector employed, in 2017, 5% of the total number of workers in the city of Barcelona, a figure that means close to 55,000, in absolute values (Barcelona Activa, 2018).[10] The dynamism throughout this decade has been spectacular, with an increase of more than 35% (and more than 14,000 new workers), compared to the variation of less than 10% in the whole city. In the Catalan context, the relative weight of the city of Barcelona in the sector is capital and superior to that of the city in the total of the economy. 55% of the total workers in the ICT sector in Catalonia are located in the city of Barcelona (33% for the economy as a whole). The working conditions in the ICT sector are clearly positive, comparatively. Thus, more than half of the new contracts are indefinite (less than 15% in all the sectors of the city) and the average salary exceeds 36,000 gross Euros per year, more than 25% above the average salary of those employed in Barcelona.

Other noteworthy strategic sectors in the city of Barcelona in relation to ICT and knowledge-based (Barcelona Activa, 2018)

> *Barcelona is among the nine main European cities supporting digital entrepreneurship, according to the European Digital City Index*

are also, first, health (health, pharmaceutical, biotechnology and similar activity), with more of 90,000 workers (8.5% of the total employed in the city). Here we should highlight the pharmaceutical and biotechnology industry, where Catalonia is leader in Spain and leads the R + D. More than 8% of exports from the province of Barcelona are due to medicines and about an additional 18% to the chemical sector. Second, we find creative activities, both traditional such as architecture and engineering or design or advanced activities such as software, video games and electronic publishing (more than 40,000 workers). In total, more than 12% of the people employed in the city of Barcelona worked in the creative sector, in 2017, a figure that means approximately 130,000 in absolute terms. Of the total of Catalan workers in the sector, nearly half is located in Barcelona (around 65% in the case of the software sector, with an increase in employment close to 50% in the last decade). Finally, we must also highlight the role of high and medium-high technology manufactures, where Catalonia ranks among the five European regions with more workers (the weight of the Catalan industrial GAV over the total, of more than 20%, is above the Spanish and the EU average). The Barcelona area is responsible for about one fifth of Spanish exports, which include the chemical and pharmaceutical sector as well as the automotive sector. In this sense, the industry is located more in the metropolitan area of Barcelona than in the city itself, where close to 90% of workers are in the service sector.

Barcelona is highly positioned within the international context regarding many indicators which are capital for most cutting-edge and substantial sectors for the digital economy, as highlighted by Observatori Barcelona (2018).[11] This is an indication of the city's strength to become a more advanced knowledge hub. Thus, for example, Barcelona ranks among the 24 main cities in the world in terms of global competitiveness (eleventh in Europe), according to the Global Power City Index of the Mori Memorial Foundation, which analyzes 42 large cities and 70

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8 Ministry of Industry, Energy and Tourism (2015). *Libro blanco para el diseño de las titulaciones universitarias en el marco de la economía digital.*
9 Roland Berger (2016). "España 4.0. El reto de la transformación digital de la economía"; ACCIÓ (2018). *El sector TIC a Catalunya.*
10 Barcelona Activa (2018). *Els sectors estratègics a Barcelona.*

11 Observatori Barcelona (2018). *Informe 2017.*

indicators. Likewise, it ranks among the eight cities in the world with the best reputation, according to the City RepTrak of the Reputation Institute, which considers the 56 main cities by population and GDP and is based on surveys. In addition, according to the Global Cities Investment Monitor, of KPMG, Barcelona ranked eighth among the main urban areas worldwide in attracting foreign investment projects in the 2013-2017 period. Barcelona also stands out, according to the Global Entrepreneurship Monitor data, in entrepreneurship, with a rate of entrepreneurial activity (REA) of 7% (newly set up companies of less than three months of activity, and new companies, between three and 42 months, in percentage of the resident population aged 18 to 64). This rate, identical to the global Catalan rate, is clearly higher than the figure for Spain as a whole (5.2%) and also for Germany or Italy, despite still being below the EU REA (8.1%) and far from the United States (above 12%). Finally, Barcelona is third in the world ranking by number of international congresses organized and number of delegates sent to these congresses is also noteworthy, according to the International Congress and Convention Association (ICCA), with the outstanding presence of the Mobile World Congress.

On the other hand, in the field of knowledge and technology, Barcelona is among the nine main European cities supporting digital entrepreneurship, according to the European Digital City Index, which analyzes the 60 most important European cities. At the same time, Barcelona is considered the fifth most important start-up hub in Europe, according to the EU-startups ranking, and the third most attractive European city to establish a startup, according to Atomico. Likewise, according to the Innovation Cities Index, prepared by the consultancy 2thinknow, which analyzes up to 500 cities in the world and 162 indicators that measure the right conditions for the creation of innovation, Barcelona is positioned as the thirteenth largest city in the world and the fifth in Europe. Finally, it can be noted that Barcelona is among the top five European cities and among the first fifteen in the world in scientific academic production according to the Knowledge Cities Ranking, prepared by the Universitat Politècnica de Catalunya, with data from the Science Citation Index.

To all this we must add that the city of Barcelona is also very well positioned in the international context, following the Barcelona Observatori (2018), in other areas such as quality of life, sustainability and social cohesion; in terms of training, where it must be noted that the percentage of workers with university studies

(45%) is ten points above the EU average, as well as the fact that Barcelona is the only European city with two institutions among the ten best business schools in the world, according to the Financial Times (IESE and ESADE); or in the prices and costs, where Barcelona is still among the most competitive cities in indicators such as the rental price of offices (position 30 of 42) or the cost of living index (121 of 209 cities, according to Mercer's worldwide study Cost of Living Survey).

5. The role of universities and the structured science-technology system in Barcelona's ecosystem

Taking into account Barcelona's good ranking in the world and in Europe regarding these economic indicators and, above all, those related to knowledge and technology, the role played by universities - their faculties and schools and university research institutes - as well as the associated system of science and technology is very important. The associated system of science and technology is formed, following the ACUP (2017b)[12] and the Secretariat of Universities and Research (directorate of R + D + I), by research centres (linked to the CERCA- Research Centres of Catalonia as per its Catalan acronym-, to the CSIC - Higher Council for Scientific Research as per its Spanish acronym - and the IRTA – Agrifood Research and Technology Institute as per its Catalan acronym), by hospital institutions, by large infrastructures to support research, such as the Alba Synchrotron of the CELLS Consortium or the MareNostrum Barcelona Supercomputing Centre, by science and technology parks, technological and support centres for technological innovation of the TECNIO network,[13] by reference networks and by recognized research groups.[14] To this ecosystem we should also add companies and other entities, such as venture capital entities. The whole framework would be responsible for generating new

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12 ACUP (2017b). *Impactes socioeconòmics de les universitats públiques i el sistema públic de recerca de Catalunya.*
13 TECNIO is the certification awarded by the Generalitat de Catalunya through ACCIÓ to identify where Catalan differential technology is located, the suppliers who offer it and the facilitators who participate in the process of technology and knowledge transfer. Among the technology centres, the advanced ones stand out, which are part of Eurecat (Centre Tecnològic de Catalunya).
14 It is necessary to note that there are numerous overlaps, since most of the entities in this system belong to or are related to universities, and at the same time most entities are classified under the heading of several of these groups of entities. You can consult an exhaustive list of these R + D + I units in Catalonia, at http://universitatsirecerca.gencat.cat/ca/01_secretaria_duniversitats_i_recerca/universitats_i_recerca_de_catalunya/ recerca/directori_drdi/

knowledge and transforming this new knowledge into innovations, that is, into new products and services (Testar, Parellada and Nieva, 2015).[15]

The universities in the metropolitan area of Barcelona (AMB for its Spanish acronym) are the public Universitat de Barcelona, Universitat Autònoma de Barcelona, Universitat Pompeu Fabra, Universitat Politècnica de Catalunya, the private universities of Universitat Ramon Llull, Universitat Abat Oliba, Universitat Internacional de Catalunya and the distance learning Universitat Oberta de Catalunya.[16] The public Catalan universities Universitat Rovira i Virgili, Universitat de Lleida and Universitat de Girona, as well as the private Universitat de Vic-Central de Catalunya, would be beyond the reach of Barcelona and its closest area of influence. Thus, we observe that the vast majority of the Catalan university system is located at the AMB and the same can be said of the associated system of science and technology. As

indicated in Testar, Parellada and Nieva (2015, p.10), the R + D and innovation system in Barcelona and its metropolitan area represents between 80% and 90% of the whole Catalan system, depending on the parameter to be considered.

Among the conclusions of Testar, Parellada and Nieva (2015), it should be noted that Barcelona and its metropolitan area have developed an innovation ecosystem that has remarkably evolved since the beginning of the century and that, even with the crisis, has managed to consolidate itself. However, it needs to grow more in size and above all in maturity to be able to increase its efficiency.

The results of a series of research indicators (resources and results, in the form of publications) and technology transfer are presented below. These indicators either make it possible to compare internationally the positioning of Barcelona and Catalan universities and their associated bodies, or they serve to highlight the importance of the universities in the Barcelona metropolitan area and the linked ecosystem of science and technology in Catalonia and Spain as a whole.

A. Gross domestic expenditure on R&D as a percentage of GDP

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15 Testar; M. Parellada; C. Nieva. (2015). *Estat actual i impacte de l'R+D i la innovació a l'àrea metropolitana de Barcelona*. **Consell Econòmic i Social de Barcelona.**
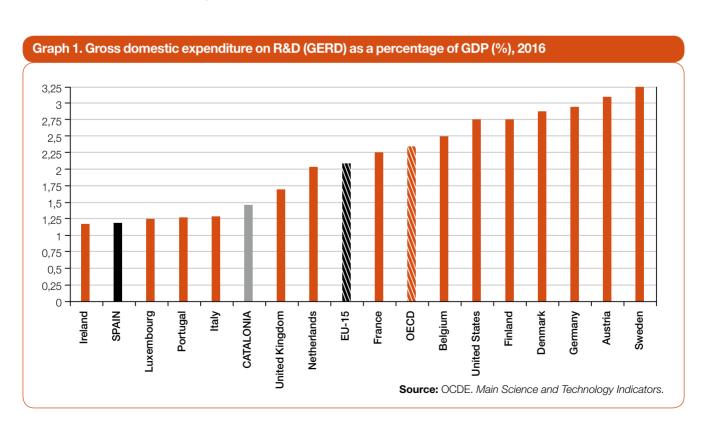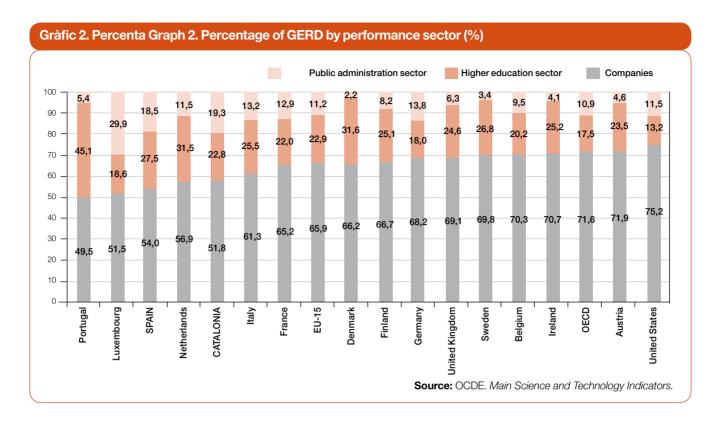
16 However, it is important to clarify that some centres and faculties of these universities are outside the metropolitan area of Barcelona, such as the centres in Terrassa or Manresa belonging to the Universitat Politècnica de Catalunya.

Graph 1. Gross domestic expenditure on R&D (GERD) as a percentage of GDP (%), 2016

Source: OCDE. *Main Science and Technology Indicators.*

Gràfic 2. Percenta Graph 2. Percentage of GERD by performance sector (%)

Source: OCDE. *Main Science and Technology Indicators.*

Regarding this first indicator, first of all it is necessary to point out that in 2016 the gross domestic expenditure on R&D as a percentage of GDP in Catalonia was 1.46%, higher than the total for Spain (1.19%) and in Portugal or Italy, for example, in the European context, as can be seen in figure 1, but lower than the data for the EU-15 and the OECD (2.09 and 2.34 %, respectively) and of most European countries. A second noteworthy issue is that a reduced, compared at international level, proportion of R + D expenditure is executed by companies in Catalonia: 57.8%, about four percentage points above Spain but far from the 65.9% of the EU-15 and still more than 71.6% of the OECD. In contrast, a comparatively larger expenditure is performed by the public administration sector (figure 2); if this expenditure is compared to GDP, Catalonia appears above the OECD and the EU-15 (0.28% vs. 0.26 and 0.23%). In the case of considering the expenditure on R + D of higher education as a percentage of GDP, the data obtained by Catalonia in 2016, of 0.33%, was also lower than that of the OECD (0.41%) and the EU -15 (0.48%). Third, we can also highlight the fact that while the expenditure on R&D as a percentage of GDP continued to increase in the EU-15 and the OECD during the crisis, in Catalonia, as in Spain, it fell from 2010 onwards and had not recovered yet in 2016 (figure 3). By sectors of performance, in this last decade the relative weight of companies in total R + D expenditure has

decreased; also, but less, only half a point, that of the higher education sector and that of public administration has clearly increased. The evolution has been exactly the opposite in the EU-15 and the OECD, as can be seen in table 1.

B. Resources obtained by Catalan public universities for research and innovation

Secondly, it can also be highlighted that in 2016 public universities in the metropolitan area of Barcelona (including their research institutes and associated technology centres) managed to obtain more than 295 million Euros for research and innovation, both competitive and non-competitive funds, a figure that represents 86% of the total collected by Catalan public universities. Around 74% of the funds came from competitive financing channels. Of these, the great majority, 58%, came from the State Administration and about an additional 30% came from Europe. The participation of each AMB university in these funds is shown in figure 4, where the Universitat Politècnica de Catalunya stands out in attracting non-competitive and competitive funds from European administrations, Pompeu Fabra in the competitive funds granted by the Generalitat and the University of Barcelona in the competitive ones coming from the State Administration. On the other hand, if the funds collected by full-time equivalent teaching and research staff are compared (PDI ETC for its

Spanish acronym), as shown in Table 2, the Universitat Pompeu Fabra is clearly the most outstanding, except in terms of the non-competitive funds, where the Politècnica de Catalunya stands out, with just over 12,000 Euros for each full-time professor.
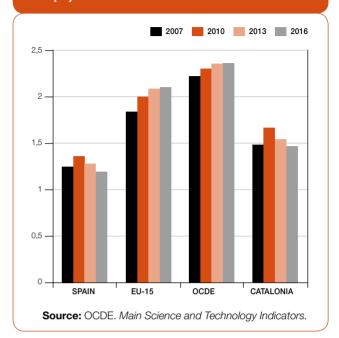
C. Publications, quantity and quality

With regard to the results of the research, the scientific publications made during the 2012-2016 five-year period by the research institutions are analyzed, based on the data found in the Scopus database. In this period, a total of 126 Spanish research institutions published at least a thousand documents. Of these, there are 31 Catalan and 27 belong to the metropolitan area of Barcelona (more than one in five Spanish, then). Apart from the universities, there are 15 institutions from the health sector (14 at the AMB) and seven institutions from the public administration sector. Not only the relative presence of these institutions in Barcelona is important quantitatively, but some of them are also very well placed in the international context, and hold positions among the top 100-150 in the world, in aspects related to quality, such as the normalised impact of publications (as can be seen in Table 3, in all cases far above the world average),[17] the citations received per document or the percentage that represents excellence in publications (which belong to the 10% of documents with more citations in their field).

Focusing specifically on universities, it should be noted that

17 Of all the Spanish regions, in fact, Catalonia has the greatest standardised impact of its publications: 1.62, which means that on average it has more than 60% more citations than the world average, compared to 1.32, for example, in Madrid. Following Catalonia, in terms of this indicator, there is Cantabria (1.54) and the Balearic Islands (1.45), always considering the period 2012-2016, and the whole scientific production of the Spanish autonomous communities (Fundación CYD's report, 2018)

Graph 3. Evolution of GERD as a percentage of GDP (%) 2007

Source: OCDE. *Main Science and Technology Indicators.*

many of the ones in the AMB are very well placed in Spain, and occupy, even, leadership positions, if we take the number of publications made in the last five years regarding teaching personnel and full-time researchers, or also if indicators on quality are included, such as the normalised impact, the percentage of publications in the most important journals of their scientific field or the percentage of documents of excellence led by professors of the university (table 4). In this sense, the publications made in the 2012-2016 five year period by the universities of the Barcelona area represent 84.5% of the total of Catalonia and 19.1% of the total of the Spanish university system (considering the 61 universities that published more than one hundred documents in Scopus during the year 2015).
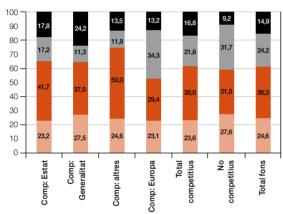
Table 1. Evolution of the percentage of GERD by performance sector (%)

	2007			2016		
	Companies	Higher education sector	Public administration sector	Companies	Higher education sector	Public sector administration
SPAIN	56,0	26,4	17,6	54,0	27,5	18,5
UE-15	65,2	22,4	12,5	65,9	22,9	11,2
OCDE	71,4	17,2	11,4	71,6	17,5	10,9
CATALONIA	63,0	23,3	13,7	57,8	22,8	19,3

Source: OCDE. Main Science and Technology Indicators.

Graph 4. Resources collected by public universities of the AMB for research and innovation, by type of funds (%), 2016

	UAB	UB	UPC	UPF
Comp: State	23,2	41,7	17,2	17,8
Comp: Generalitat	27,5	37,0	11,3	24,2
Comp: others	24,6	50,0	11,8	13,5
Comp: Europe	23,1	29,4	34,3	13,2
Total Competitive	23,6	38,0	21,6	16,8
Non-competitive	27,6	31,5	31,7	9,2
Total funds	24,6	36,3	24,2	14,9

Source: Uneix. Secretaria d'Universitats i Recerca. Departament d'Empresa i Coneixement.

Table 2. Resources collected by public universities of the AMB for research and innovation, by type of funds, divided by PDI ETC, 2016 in Euros

	UAB	UB	UPC	UPF
Comp: State	13.640	16.747	11.187	33.021
Comp: Generalitat	2.332	2.143	1.062	6.467
Comp: others	947	1.318	505	1.644
Comp: Europe	6.938	6.060	11.449	12.526
Total Competitive	23.857	26.268	24.203	53.657
Non-competitive	9.705	7.567	12.332	10.206
Total funds	33.562	33.834	36.535	63.864

Source: Uneix. Secretaria d'Universitats i Recerca. Departament d'Empresa i Coneixement.

Table 3. Catalan research institutions in the world ranking of research institutions, 2012-2016

Rank	Value	Institution	Category
33	2,98	Institut de Física d'Altes Energies	Public Adm.
42	2,83	Centre de Regulació Genòmica	Health
55	2,71	Institut de Salut Global de Barcelona	Health
116	2,36	Institució Catalana de Recerca i Estudis Avançats	Public Adm.
		Hospital Universitari Vall d'Hebron	Health
132	2,32	Institut Català d'Oncologia, Hospitalet de Llobregat	Health
142	2,29	Institut d'Investigacions Biomèdiques August Pi i Sunyer	Health
		Hospital Clínic i Provincial de Barcelona	Health
145	2,29	Institut Hospital del Mar d'Investigacions Mèdiques	Health
		Hospital de la Santa Creu i Sant Pau	Health
157	2,27	Institut d'Estudis Espacials de Catalunya	Public Adm.
		Barcelona Supercomputing Center	Public Adm.
181	2,21	Centre Tecnològic de Telecomunicacions de Catalunya	Public Adm.
		Hospital del Mar	Health
210	2,16	Institut d'Investigació Biomèdica de Bellvitge	Health
264	2,04	Institut de Ciències Fotòniques	Public Adm.
		Universitat Pompeu Fabra	Higher Education
303	1,99	Hospital Universitari de Bellvitg	Health
374	1,89	Hosp. Universitari Germans Trias i Pujol	Health
		Inst. de Recerca Biomèdica Barcelona	Health
378	1,89	Universitat de Barcelona	Higher Education
403	1,86	Universitat Autònoma de Barcelona	Higher Education
		Universitat Rovira i Virgili	Higher Education
410	1,85	Institut d'Investigació i Innovació Parc Taulí	Health
473	1,80	Institut de Recerca i Tecnologia Agroalimentàries Barcelona	Public Adm.
512	1,78	Universitat Oberta de Cataluny	Higher Education
566	1,73	Universitat de Lleida	Higher Education
		Universitat Politècnica de Catalunya	Higher Education
707	1,63	Universitat de Girona	Higher Education
		Hospital de Sant Joan de Déu d'Esplugues de Llobregat	Health
819	1,56	Universitat Ramon Llull	Higher Education
852	1,54	Universitat Autònoma de Barcelona	Ed. Superior
933	1,50	Universitat Rovira i Virgili	Ed. Superior
995	1,47	Institut d'Investigació	
		i Innovació Parc Taulí	Salut
1.047	1,43	Institut de Recerca i Tecnologia	
		Agroalimentàries Barcelona	Adm. pública
1.179	1,37	Universitat Oberta de Catalunya	Ed. Superior
1.333	1,29	Universitat de Lleida	Ed. Superior
1.326	1,29	Universitat Politècnica de Catalunya	Ed. Superior
1.350	1,28	Universitat de Girona	Ed. Superior
1.482	1,22	Hospital de Sant Joan de Déu	
		d'Esplugues de Llobregat	Salut
1.498	1,21	Universitat Ramon Llull	Ed. Superior

Note: institutions that published more than one thousand documents from 2012 to 2016. **Source:** Scimago Institutions Rankings from Scopus database. Data extracted from the Fundación CYD (2018)

Table 4. Universities of the AMB, publications 2012-2016 by PDI ETC

	s/PDI ETC, Curse 2016-17	Position among 61 Spanish universities	Normalized impact	Position among 61 Spanish universities	% production in Q1	Position among 61 Spanish universities	% excellence in leadership	Position among 61 Spanish universities
Universitat Autònoma de Barcelona	10,11	2	1,57	3	59,37	7	7,67	15
Universitat de Barcelona	8,14	3	1,60	2	63,78	1	7,50	18
Universitat Internacional de Catalunya	*3,92*	*38*	*1,23*	*22*	*52,10*	*26*	*5,73*	*45*
Universitat Oberta de Catalunya	*4,96*	*21*	*1,49*	*6*	*29,24*	*58*	*8,28*	*8*
Universitat Politècnica de Catalunya	7,79	5	1,29	13	42,55	49	8,09	11
Universitat Pompeu Fabra	10,79	1	1,82	1	61,66	3	10,12	2
Universitat Ramon Llull	*2,37*	*54*	*1,25*	*21*	*51,21*	*27*	*6,19*	*39*

Note: universities with more than one hundred documents in Scopus in 2015. Data from 2016, provisional. In italics, private and distance learning universities. % production in Q1 refers to publications in the first quartile (25%) of the most important journals in their field, by impact. The % of excellence with leadership refers to publications led by university professors and that are within the 10% of documents that have received the most citations in their field.
Source: Scimago Institutions Rankings from the Scopus database and Statistics of university staff. Sistema Integrado de Información Universitaria (SIIU), Ministry of Education, Culture and Sports. Data extracted from the CYD Foundation (2018).

As the ACUP (2017a) [18] points out, the efficiency of the Catalan research system must be valued, in the sense that it has a high normalised impact factor despite the fact that gross domestic expenditure on R&D as a percentage of GDP in the case of higher education sector (adding, even, the public administration sector) is clearly below the average of the most advanced surrounding countries (EU-15) or the OECD.

D. Patent application

In the field of technology transfer, first of all, we must mention the patent application indicator. In the last decade, around 15% of the national patent applications to the OEPM (Spanish Patent and Trademark Office for its Spanish acronym) came from the province of Barcelona.[19] Within Spain, only Madrid exceeds Barcelona, with 20%. In the case of the PCT[20] patents submitted to the OEPM, the relative weight of the province of Barcelona in the last decade is slightly higher, at 16%, second behind Madrid (24%, in this case). Of the national patent applications and PCT registered in the last decade to the OEPM, approximately 9-12% of Catalonia and 14-17% of Spain were applications made by the universities.

Also in relation to this indicator, Barcelona's universities are very well situated in the context of the Spanish university system, even though their comparative position would not be as good as that observed for scientific publications, with the exception of the Universitat Politécnica de Catalunya, positioned among the first three Spanish universities (leader, notably, in the case of the applications of international patent extensions per professor) compared to the -also meritorious- fifth place in the case of publications by PDI ETC (i.e. full-time equivalent of teaching personnel). National patent applications made in the period 2006-2016 by the universities of the AMB represent 87.4% of those of the Catalan university system and 10.6% of the total of those carried out by all the Spanish universities with data. The respective percentages in the case of PCT patents would be 85.1% and 11.7%.

E. Spin-offs and income from knowledge transfer activities

Continuing in the field of technology transfer, other reference indicators would be spin-offs and income from knowledge transfer activities. According to the ACUP (2017a), in 2015 113 spin-offs were active throughout Catalonia (technology-based companies derived from the university). Of the universities in the metropolitan area of Barcelona there were 89, that is, 78.8% of all the active spinoffs in Catalonia. In terms of individual universities we must highlight the Universitat Politècnica de Catalunya, with slightly more than half of these companies active in the Barcelona area (46 spin-offs), followed by the Universitat de

18 **ACUP (2017a).** *Indicadors de recerca i innovació de les universitats públiques catalanes. Informe 2016.*
19 **The residence of the first applicant is in the province of Barcelona.**
20 **PCT's patents (Patent Cooperation Treaty) allow guaranteeing the international protection of inventions**

Barcelona, with 21, and the Universitat Autonoma de Barcelona, with 14 (approximately the same, it must be said, in the Catalan area, that the Universitat Rovira i Virgili de Tarragona, with 15). The rest of the active spin-offs in 2015 corresponded to the Universitat Pompeu Fabra (7) and Universitat Oberta de Catalunya (1). Although, as indicated by Testar, Parellada and Nieva (2015), these companies that emerged from universities (and also those derived from research groups) have seen limited growth, with few exceptions. This would be indicative that these spin-offs are created within the framework of an innovation ecosystem that is not yet mature enough. One of the limiters, in this sense, would be the venture capital, which represents 0.03% of the GDP of Catalonia, far from the 0.17% in the United States.

Following ACUP (2017a), we can also highlight the fact, in this area, that Catalan universities generated 24% of total revenues in 2014 due to knowledge transfer activities corresponding to the whole of the Spanish university system, even though these amounts are limited. Thus, more specifically, by concept, they generated 19.3% of the amount of R + D + I contracting (equivalent to 63 million Euros), 36% of the amount of public financing projects of collaboration with companies (and 42.5 million Euros) and approximately a quarter of the income from licenses (equivalent to only 0.75 million Euros).

6. Conclusion

The ecosystem of Barcelona's metropolitan agglomeration has a relevant role in the Spanish economy as a whole and, in some aspects, certain indicators –notably the quantity and quality of scientific publications- show us an outstanding international position. In addition, even with the impact of the crisis, the strengthening of the ecosystem, especially in some activities, particularly biotechnology, has been notable, and the presence of associated services has increased, with the outstanding presence of national and international venture capital funds.

Everything seems to indicate that the bases are being created so that the metropolitan region of Barcelona can have the characteristics of the ecosystems that constitute the hubs of innovation. To achieve this, it is necessary to invest the necessary resources and do so with the aim of making the Barcelona ecosystem an environment capable of competing on a world scale, which is where these ecosystems operate. In order to reach this objective, the public administration responsible need to make a clear and shared decision, also intended to deploy the essential social pacts.

LOCATION PATTERNS

OF INNOVATION SECTORS AT METROPOLITAN SCALE

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This paper[1] analyzes the location patterns at a metropolitan scale of the most intensive sectors in innovative activities and, in particular, those linked to ICT (information and communication technologies). The innovative capacity of these sectors is largely explained by the external environment to the company. Because of that they tend to cluster in the central nucleus of the metropolitan areas where they can benefit from the external knowledge generated as a result of this concentration. This paper carries out a location analysis of the intra-sector scope and also shows what inter-sector links are found between innovative sectors in terms of their location preferences and the physical proximity between companies from different sectors.

1. Motivation

The activities linked to ICT (Information and Communication Technologies) have experienced a strong expansion in Catalonia in recent years, especially in the metropolitan area of Barcelona where companies connected to these sectors find an economic and financial environment more convenient for their location requirements. In addition to this clear preference for the metropolitan environment of Barcelona, ICT activities show a tendency towards agglomeration much more intensely than other sectors, as a result of the close interdependencies between companies in related sectors.

ICT activities have traditionally been at the epicentre of growth strategies carried out by cities in the most developed countries due to the numerous positive externalities linked to them. In this regard, ICT activities generate highly qualified employment in technology-intensive activities. They collaborate to establish a whole network of companies that provide specialized services for companies in the sector (also in technology-intensive activities), give prestige to the territories where they are located in and do not cause negative externalities in environmental terms or linked to land uses.

In Catalonia, the ICT sector is one of sectors with a greater capacity for growth and generation of employment. Thus, in 2015 there were more than 84,000 direct jobs in this sector (with average salaries higher than 30,000 Euros per year). The sector in general contributed more than 15,000 million Euros to GDP, which represents around 25% of the GDP of the ICT sector of the State (Instituto Nacional de Estatística, 2015). Raising capital is another indicator of business dynamism. In this sense, in the same year it obtained more than 324 million Euros of investment in technological start-ups, which represents more than 60% of the total investment in start-ups in the Spanish State (Instituto

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Nacional de Estadística, 2015). Thus, due to the importance of this sector several public policies regarding the deployment of electronic communication infrastructures have been made to guarantee the competitiveness of the involved companies. The agglomeration of Barcelona (and the city in particular) stands out for using ICTs in very different areas of daily life due to the high availability of ICT infrastructures (such as the fibre optic network or the municipal Wi-Fi network). It also stands out for the ability to attract talent in these sectors thanks to a high quality of life, and the existence of leading companies that not only attract others but also stimulate the creation of start-ups around them (the cases of T-Systems, Yahoo, Microsoft or Hewlett Packard, among others). Additionally, there are support networks for research and technology transfer that allow improving the competitive capacity of companies. In addition, the dynamism of the sector is explained by milestones such as the presence of the Mobile World Conference in Barcelona in 2012, an event that reinforced Barcelona as the capital of the mobile telecommunications subsector and collaborated to attract new companies in the sector.

This paper aims to analyze the location dynamics of companies within the ICT sector in the metropolitan agglomeration of Barcelona from the role played by the ICT activities in the processes of economic growth experienced by the main European metropolitan agglomerations. Thus, the interest of this paper goes beyond knowing where these companies are located within the metropolitan area and focuses on analyzing in detail what dynamics of agglomeration occur between companies belonging to ICT activities. This is a key point for their competitiveness, given that the large empirical evidence available suggests the existence of close relationships of interdependence between the various ICT sectors, relationships that also have a translation in terms of physical proximity.

2. Data and methodology used

The territorial scope under analysis is made up of the Metropolitan Area of Barcelona (AMB) with the addition of a set of close by municipalities that take part in the metropolitan life and that have strong interactions in terms of labour markets and of forced daily commute. Specifically, the paper uses the first three zones of the geographical area of the Integrated Tariff System of the Barcelona area, which includes a total of 102 municipalities.[2]

2 Out of these municipalities, 17 belong to zone 1, 43 belong to zone 2 and 42 belong to zone 3.

2.1 Data

The data related to companies belonging to the ICT sectors (Information and Communication Technologies) come from the Sistema de Análisis de Balances Ibéricos (SABI) database compiled by INFORMA D & B and Bureau Van Dijk, with information from the Mercantile Registry. This database contains exhaustive information at company level and has an increasing coverage of the business sector.

Table 1 shows the list of sectors under analyse for the years 2006, 2010 and 2015. The use of the aforementioned years allows us to check for the spatial distribution of ICT companies for the previous (2006), later (2015) and central (2011) periods of the crisis, in order to avoid any bias caused by it.

2.2 Methodology: the M functions

This paper uses the M function to evaluate the concentration and agglomeration[3] of ICTs in the extended metropolitan area of Barcelona. This function, introduced by Marcon and Puech (2009, 2003), is a relative function based on distance that allows comparing the proportion of companies of interest in a specific area in relation to the proportion of companies of interest in the area of reference as a whole. The M function can be interpreted as the equivalent to the localization coefficient from a

3 In this paper, the term concentration refers to a group of companies from the same sector, whilst the term agglomeration is used for a group of companies from different sectors.

Table 1. ICT activity sectors

Activity	Acronym	CNAE 2009 (3 DIG)
Software editing	EPI	582
Cable Telecommunications	TC	611
Wireless telecommunications	TSF	612
Satellite telecommunications	TS	613
Other telecommunications activities	AT	619
IT Services	STI	620
Data processing, hosting and related activities; Web portals	PHW	631
Total activities	TIC	-
Rest of economic activity	RAE	-

Source: authors' elaboration based on data from SABI

distance-based perspective.[4] The results obtained allow us to identify whether there is significant concentration or agglomeration (dispersion), if the proportion of companies of interest in the area of reference is higher (lower) than that of the whole area of study.

Among the advantages of using the M function, we can highlight the fact that it allows us to control for the global concentration patterns of each sector, as well as industrial concentration, which remains unchanged between different geographical scales and which allows us to verify the statistical significance of the results (Lang et al., 2015; Marcon and Puech, 2009). In addition, this function stands out as it takes into account the existence of heterogeneous geographical spaces and facilitates the interpretation and comparability of the results in a direct and simple way.

In this paper, the M function is calculated for each 1,000 meters in a radius between 0 and 60 km thanks to the use of micro-data corresponding to the companies located in the extended metropolitan area. The dbmss package (Marcon et al., 2015) available in the free R statistical software has been used for the estimation.

Function M: concentration at intra-industry scale

The function M used to calculate the spatial concentration at intra-industry scale in a circle of radius r for a sector S is defined as follows:

$$M(r, S) = \sum_{i=1}^{N_S} \frac{e_{iSr}}{e_{ir}} \bigg/ \sum_{i=1}^{N_S} \frac{E_S - e_i}{E - e_i}$$

where $i = 1, 2, ..., n$ is a company index, e defines the number of companies in the reference area and E is the total number of companies in the whole area. Its estimation is organized in different phases. At the beginning, all the companies belonging to S sector are identified in the area under analysis. In this paper,

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4 The location quotient (LQ) is defined as LQ= (Lij,/ Lj) / (Li / L), where Lij is the number of companies of the industry j in the region i; Lj is the total number of companies in the industry j; Li is the total number of the companies in region i, and L is the total number of companies in the area (for instance, region or country). LQ values over 1 indicate that the concentration of the industry j in the region i is higher than the average of all the territory under analysis, therefore this region is specialized in the specific industry.

an S sector refers to companies in the ICT sectors. Around each of these companies, a circle of radius r is drawn (for example, 1 km). Within this distance, the number of companies that are part of the sector S ($eiSr$) are counted. Next, the sum of these companies on i is defined as the proportion of the number of companies in all sectors of economic activity within the same circle. Finally, this quotient is divided by that of sector S in the totality of the economic activity of the whole extended metropolitan area.

The reference value to be able to interpret the M function is 1, so that values of M equal to 1 indicate that, for any considered radius, proportionally there is the same number of companies from sector S than from the whole area analyzed. This result indicates that the location of companies in sector S is random. Values of M greater than 1 indicate that there are proportionally more companies close to companies in sector S in a radius r than in the area as a whole, that is, that there is a geographical concentration relative to that of sector S at a distance r. Finally, values of M lower than 1 indicate that there are relatively fewer companies in sector S within a radius r than in the whole area, in other words, that sector S is relatively dispersed at distance r.

The statistical significance of the M function is calculated by the construction of confidence intervals for the null hypothesis based on the independence of the location of the companies (in this case, that the companies that are part of the S sector are located following the same pattern as the rest).

The use of the Monte Carlo method allows defining the confidence intervals in the following way. First, a large number of simulations (1,000) are generated. Secondly, a confidence level of 5% is fixed, so that 95% of the confidence interval of the M for each value of r is limited by the remaining 5% of the randomly generated values. Thus, there is significant relative concentration (dispersion) in the analyzed sector if the corresponding values of M are higher (lower) than 1 and fall outside the bands of the confidence intervals.

Function *M*: agglomeration at inter-industry scale

The inter-industry version of the M function analyzes the existence of agglomeration. Specifically, the agglomeration functions M for sectors $S1$ and $S2$ are defined similarly to the definition of $M(r, S)$ but, in this case, the denominator slightly varies:

$$M_{S_1S_2}(r) = \sum_{i=1}^{NS_1} \frac{e_{iS_2}r}{e_{ir}} \bigg/ \sum_{i=1}^{NS_1} \frac{E_{S_2}}{E - e_i}$$

$$M_{S_2S_1}(r) = \sum_{i=1}^{NS_2} \frac{e_{iS_1}r}{e_{ir}} \bigg/ \sum_{i=1}^{NS_2} \frac{E_{S_1}}{E - e_i}$$

Thus, M_{S1S2} (M_{S2S1}) illustrates the spatial structure of companies in sector $S2$ ($S1$) that are located around the sector $S1$ ($S2$). The value indicates whether the relative density of the companies $S2$ ($S1$) located around the companies in the sector $S1$ ($S2$) is higher or lower than the density observed in the whole area. The statistical significance of the inter-industrial function of M is evaluated following the same methodology as in the case of the intra-industrial function presented above, although the construction of confidence intervals is slightly more complicated. Significant values of M (r, $S1$, $S2$) can be explained either by the possible interaction between sectors or by specific patterns for each of the sectors $S1$ or $S2$. Thus, the null hypothesis should control for both cases. In this way, the null hypothesis of all the points for $MS1S2$ (r) is generated by keeping the points of $S1$ unchanged and redistributing all the rest of the points in all other possible locations. The same process is applied for $S2$. In this sense, there will be significant agglomeration as long as both values are significantly different from their respective null hypotheses (Marcon and Puech, 2009).

3. Results

3.1. Descriptive analysis

Among other factors, the interest of the ICT sector lays in its dynamic behaviour in a context of crisis and slowing down of economic activity. Thus, a look at table 2 shows how in the period from 2006 to 2015 the number of ICT companies in the area under study remained slightly high, while companies belonging to the rest of the sectors experienced a decline by 3.3%. In a context of crisis and post-crisis, the results of ICT show the

resilience of the sector and the goodness of the sector specialization strategy in these activities.

In addition, these are sectors with certain stability (at least during the period analyzed). In terms of the inflows and outflows, table 3 shows there is a high persistence in terms of the companies that continue in the market throughout the period, given that the rotation (inflows plus outflows) only represents 8.8% of the stock in 2010 and 6.6% in 2015.

To have an initial overview of the distribution of ICT companies in the metropolitan area of Barcelona, figure 1 shows a heatmap indicating the density of ICT companies. As could be expected, almost all ICT companies are located in urban areas and, among them, the cases of Barcelona and Sant Cugat del Vallès stand out, a pattern that is stable between 2006 and 2015.

Regarding the location of each of the ICT sectors, Figure 2 shows the existence of subsectors such as editing software (EPI for its Catalan acronym), cable telecommunications (TC for its Catalan acronym), wireless telecommunications (TSF for its Catalan acronym) and satellite telecommunications (TS for its Catalan acronym) with a low number of companies and a location, in general, in the central areas (a pattern that in the case of
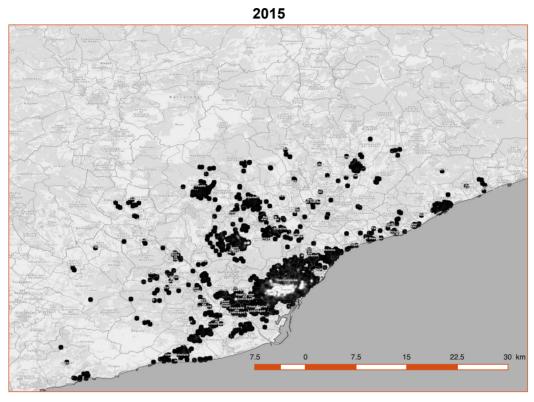
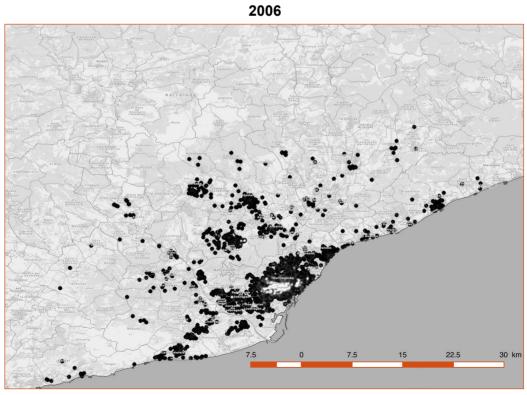### Table 2. Temporary evolution of ICT Companies (2006, 2010 i 2015)

Sectors TIC	2006	2010	2015
EPI	59	63	61
TC	37	40	37
TSF	15	13	13
TS	6	6	6
AT	387	392	382
STI	3.312	3.365	3.358
PHW	196	197	201
Total TIC	4.012	4.076	4.058
	2,55%	2,60%	2,67%
RAE	153.464	152.918	148.159
	97,45%	97,40%	97,33%
Total	157.476	156.994	152.217
	100,00%	100,00%	100,00%

EPI (software editing), TC (cable telecommunications), TSF (wireless telecommunications), TS (Satellite telecommunications), AT (other telecommunications activities), STI (IT services), PHW (Data processing, hosting and related activities; Web portals) and RAE (Rest of economic activity).
Source: authors' elaboration based on data from SABI

Graph 1. Spatial distribution of ICT companies (2006 i 2015)

2015

2006

Graph 2. Spatial distribution of ICT subsectors companies (2015)

EPI

TC

TSF

TS

AT

STI

PHW

Source: authors' elaboration based on data from SABI
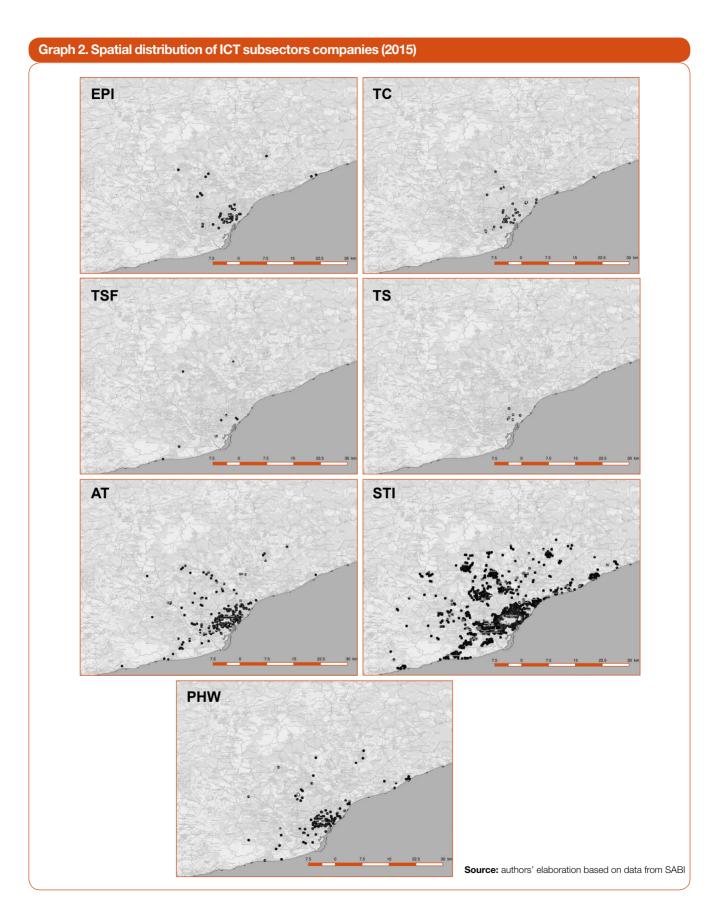
Table 3. ICT companies evolution (2006, 2010 i 2015)

	2006	2010	2015
Total TIC	3.923	4.077	4.059
Inflow	-	256	124
Outflows	-	102	142
Remain	-	3.821	3.935

Source: authors' elaboration based on data from SABI

TC, TSF and TS is partly explained by the high level of specialization with a very limited demand and with relatively high operating costs); while the subsectors information technology services (STI for its Catalan acronym), other telecommunications activities (AT for its Catalan acronym) and data processing, hosting and related activities; Web portals (PHW for its Catalan acronym) have a larger number of companies and are more widespread throughout the territory, mainly due to the fact that they show an industrial structure basically of SMEs.

Among the factors that favour the spatial concentration of the ICT sectors around Barcelona, we can highlight the accessibility to the transport infrastructure, the high possibilities of interaction between companies in the same sector and related sectors, the telecommunications network, the availability of highly qualified workers and the positive effect of the Barcelona brand (Barcelona City Council, 2013, 2012, 2007). In this sense, it refers to location appeal with a high persistence, which generates a path dependence in the spatial distribution of companies.

3.2 Intra-industry concentration

Regarding the analysis of geographic concentration processes, Figure 3 shows the concentration of all the ICT sectors for the years 2006, 2010 and 2015 from the use of the M function. Thus, as mentioned in Section 2 of this article, the M function allows measuring the intensity of concentration (dispersion) of economic activity in a specific territory. As for the companies in the ICT sectors, the results indicate a clear persistence in the patterns of concentration of these sectors in the extended metropolitan area of Barcelona. This way, a high concentration of ICT activities can be seen in a radius of between 1 and 2 km from which there is a rapid decrease, so that the concentration disappears around 20 km. Specifically, in 2015 (with a value of the M function of 4.40 up to the first kilometre), the concentration of ICT sectors was 4.40 times higher than the concentration of
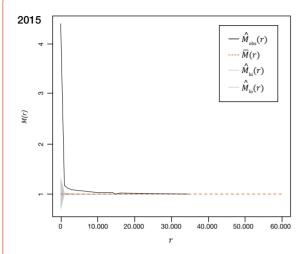
the rest of the sectors in this area. This result is robust, since it has remained fairly stable since 2006. In fact, for 2006 and 2010 the values of the M function were 4.62 and 4.98, respectively, being also significant up to around the 20 km. Therefore, these results show a clear persistence in the concentration intensity of the ICT sectors, for which the impact of the economic crisis has been lower than for the rest of the economic activities (CTecno, 2017; ASEITEC, 2014; Propris, 2013). These dynamics could be explained by factors such as the previous specialization in ICT activities, in general, and by the importance of the Barcelona's brand, in particular.
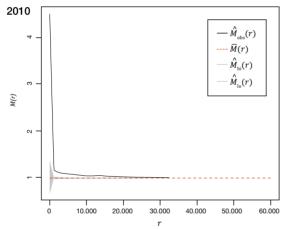
Although the previous results show some general patterns for all ICT sectors, it is necessary to see to what extent there are specificities at subsector level. In this sense, table 4 shows how the concentration patterns vary between sectors. Thus, a clear intensity of concentration is observed for most ICT sectors (with the exception of EPI and TS) within the first section of the function (0-7 km). From the second section of the function (7-14 km) the concentration loses intensity and ceases to be significant in most cases. These results confirm previous expectations about the greater incentives of ICT companies to concentrate in and around Barcelona (Coll-Martínez et al., 2019, Arauzo-Carod et al., 2017) in order to benefit from aspects such as the degree of tacit knowledge in this area that is so important in this type of activities. As several authors point out, concentration helps the transfer of tacit knowledge through direct and daily interaction between several agents (Storper and Venables, 2003). As these are highly innovative sectors, concentrating on large cities and the corresponding metropolitan area helps interaction among skilled workers as well as the transmission of innovative ideas (Henderson, 2003; Glaeser et al., 1992).
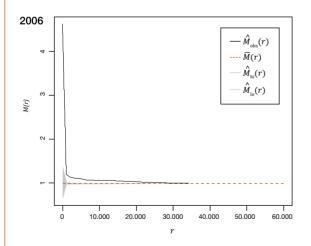
3.3 Inter-industry agglomeration

In addition to the processes of agglomeration analyzed previously, it should be noted that certain sectors tend to agglomerate with others, either because they both need the same type of environment or because there is some type of interdependence (symmetrical or not) according to which positive effects on companies in the sector are generated (arising from the geographical proximity between them). In this sense, the analysis of the location patterns of the ICT sub-sectors allows for the empirical identification of cases of significant agglomeration. To show these effects, among the various combinations of ICT subsectors, two pairs of subsectors have been selected that present significant agglomeration patterns. The first pair of subsectors

2015

Legend:
$\hat{M}_{obs}(r)$
$\overline{M}(r)$
$\hat{M}_{hi}(r)$
$\hat{M}_{lo}(r)$

2010

Legend:
$\hat{M}_{obs}(r)$
$\overline{M}(r)$
$\hat{M}_{hi}(r)$
$\hat{M}_{lo}(r)$

2006

Legend:
$\hat{M}_{obs}(r)$
$\overline{M}(r)$
$\hat{M}_{hi}(r)$
$\hat{M}_{lo}(r)$

Note: vertical axis (value M); horizontal axis (metres). A thousand simulations have been performed for each function.
Source: authors' elaboration

is made up of the software editing sector (EPI) and the rest of the ICT subsectors, while the second pair is formed by the subsector of data processing, hosting and related activities (PHW) and the rest of ICT subsectors. The results for the first pair (figure 4) show a clear tendency of agglomeration between companies in this subsector and the rest of ICT activities, which could be indicating some type of interdependence. More specifically, the results for the Barcelona area in 2015 indicate that ICT companies (not including the EPI sector) are located around the EPI subsector with a value of the M function of 3.41 (that is, more than three times of which would be expected in a scenario of random distribution of the companies), while those of the subsector EPI do it around those of the rest of the ICT subsectors with a value of the M function of 4.04 at very short distances.

The results for the PHW sector and the rest of the ICT subsectors (figure 5) are quite similar, although they show a lower intensity in the agglomeration. In this case, the results indicate that the ICT companies (not including the PHW sector) are located around those of the PHW subsector with a value of the M function of 2.88, and those of the EPI subsector do it around those of the rest of ICT subsectors with a value of 3.11 at very short distances too.

Finally, the results on agglomeration between the different ICT sub-sectors and between each of these and all of ICT activities

Table 4. Concentration of the ICT subsector in the extended metropolitan area of Barcelona using the M function. 2015

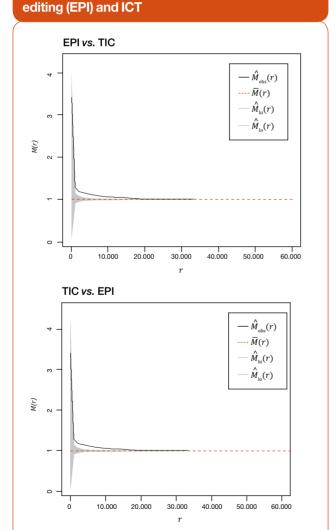|	0-7 km	7-14 km	14-60 km
EPI	NS	NS	NS
TC	C	NS	NS
TSF	C	NS	NS
TS	NS	NS	NS
AT	C	NS	NS
STI	C	CL	NS
PHW	C	NS	NS
TIC	C	CL	NS

Note: concentration (C); light concentration (CL); non-significant (NS); dispersion (D). A thousand simulations have been performed for each calculation. This same analysis has been performed for 2005 and 2010, and in general terms the same results have been obtained.
Source: authors' elaboration

are summarized in Table 5.[5] Although most subsectors are highly agglomerated with all the ICT activities (with the exception of the TSF subsector), there are important differences at the subsector level on inter-sector interdependencies in terms of geographical proximity. Thus, the agglomeration between companies in the EPI subsectors with information technology and information service (STI) activities and between the PHW and STI subsectors stand out. The agglomeration between these subsectors in the

case of the area of Barcelona can be largely explained by the fact that the companies that operate in these subsectors are located mainly in the 22 @ district, an area that has attracted companies of high technological intensity from a wide range of activity sectors (Viladecans-Marsal and Arauzo-Carod, 2012, Barber and Pareja-Eastaway, 2010). In this case, the agglomeration between these subsectors can be explained both by the interconnection of their production networks and by the effects of a cluster policy aimed at providing services potentially driving business productivity (such as spaces of more appropriate dimensions, co-working centres, accessibility to university centres for training human capital or public help, among others).

5 The values of the diagonal of the matrix are equivalent to the intra-sector concentration for the first section of table 4, as they analyze the concentration of companies of a sector around the same sector.
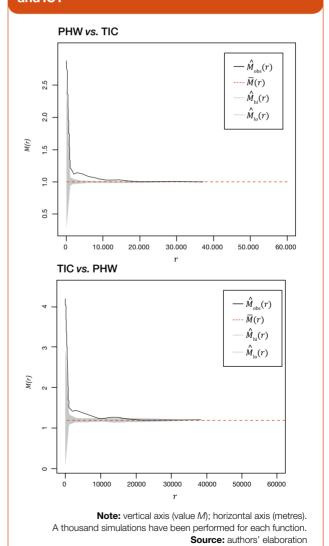
Graph 4. Agglomeration between software editing (EPI) and ICT

Note: vertical axis (value M); horizontal axis (metres). A thousand simulations have been performed for each function.
Source: authors' elaboration

Graph 5. Agglomeration between Data processing, hosting and related activities; Web portals (PHW) and ICT

Note: vertical axis (value *M*); horizontal axis (metres). A thousand simulations have been performed for each function.
Source: authors' elaboration

It is worth saying that the preceding examples of agglomeration between these subsectors and some of them with the rest of the ICT subsector support the idea that ICT activities have clear incentives to be located in the same places to have more possibilities of interaction among different economic agents. These dynamics have been identified for the same sectors in other European urban areas as Milan or Lyon (Espa et al., 2013; Moriset, 2003), where the location dynamics of highly innovative sectors such as ICTs show remarkable similarities.

4. Conclusions

This paper has focused on the Barcelona area with the aim of analyzing the concentration and agglomeration processes of companies in highly innovative sectors such as ICT (Information and Communication Technologies). These sectors tend to show location patterns highly concentrated in the central areas of the large urban areas and their immediate peripheries, due to the advantages that in terms of agglomeration economies emerge in these places. In addition to this preference for centrality and bearing in mind that knowledge spill-overs between companies are much more intense in short distances (Rosenthal and Strange, 2008), ICT companies have clear incentives to be located close to each other.

This study makes use of the relative distance-based M function and micro-geographic data from the Mercantile Registry for the years 2006, 2010 and 2015. Specifically, the results for this

function show some patterns of concentration and agglomeration of the ICT subsectors, although with notable differences for each of them, which shows how the preference for centrality and proximity to other ICT activities are modulated according to the specific characteristics of each subsector.

All in all, these results suggest that Barcelona area is an obvious magnet for these highly intensive activities in technology and knowledge, which explains why companies in these sectors are willing to bear the extra costs generated by centrality in exchange for reasonable expectations to assume efficiency improvements that are surely unreachable in other peripheral locations. Therefore, the public administrations involved should continue to support these activities to the effect that the city of Barcelona, its metropolitan area and the municipalities adjacent to it can continue to benefit from the presence of these companies and, this way, continue to stimulate the whole of the Catalan economic activity.

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Table 5. Agglomeration between ICT subsectors in the extended area of Barcelona using the M function. 2015

	EPI	TC	TSF	TS	AT	STI	PHW	TIC
EPI	*	-	-	-	-	-	-	-
TC	NS	*	-	-	-	-	-	-
TSF	NS	NS	*	-	-	-	-	-
TS	NS	NS	NS	*	-	-	-	-
AT	AL	NS	NS	NS	*	-	-	-
STI	A	NS	D	NS	A	*	-	-
PHW	AL	NS	NS	NS	AL	A	*	-
TIC	A	AL	D	AL	A	A	A	*

Note: agglomeration (A); light agglomeration (AL); non-significant (NS); dispersion (D).(*) They refer to the level of concentration (see table 4). A thousand simulations have been performed for each function. This same analysis has been performed for 2005 and 2010, and in general terms the same results have been obtained.
Source: authors' elaboration

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INNOVATION.
CITY AND COMPETIVENTESS: BARCELONA AND EUROPEAN METROPOLITAN REGIONS

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I t 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]

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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 Twenty-First Century. England: Penguin.

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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
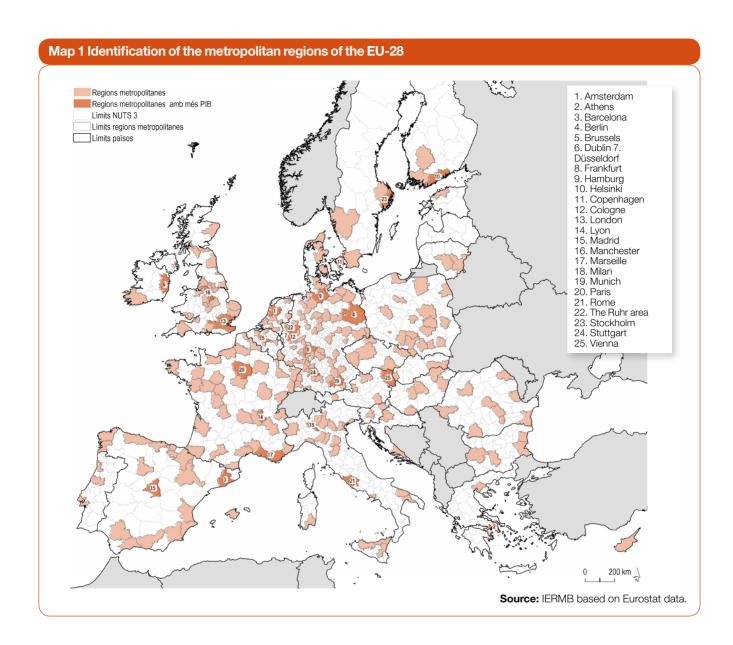
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4 European patent applications are used in this paper. This is because their geographic scope and cost are considered to reflect high quality innovations. For an analysis of Spanish patents (OEPM) see Trullén (2014); for North Americans (USPTO), see 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)

	Population	GDP M €	European patents	Population	GDP M €	European patents
				In% of the EU-28		
	(2017)	(2015)	(2014)	(2017)	(2015)	(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

Regions metropolitanes
Regions metropolitanes amb més PIB
Límits NUTS 3
Límits regions metropolitanes
Límits països

1. Amsterdam
2. Athens
3. Barcelona
4. Berlin
5. Brussels
6. Dublin 7. Düsseldorf
8. Frankfurt
9. Hamburg
10. Helsinki
11. Copenhagen
12. Cologne
13. London
14. Lyon
15. Madrid
16. Manchester
17. Marseille
18. Milan
19. Munich
20. Paris
21. Rome
22. The Ruhr area
23. Stockholm
24. Stuttgart
25. Vienna

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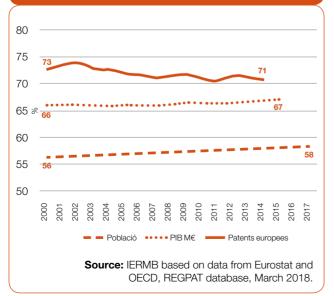
7 Patent applications have been assigned territorially based on the inventor's address (not the applicant's), as is customary in the bibliography on patents. This is due to the fact that it is considered to be the best approximate of the place where the invention is made. Therefore, the unit of analysis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

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

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

Població   PIB M€   Patents europees

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

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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

Metropolitan Region	GDP in millions of Euros (2015)	Population (2017))	European Patents (2014)	In% of the EU-28 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).
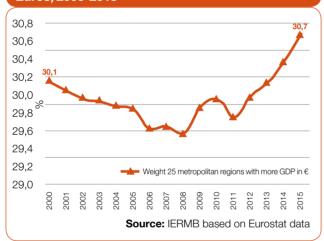
European patents in Catalonia and Barcelona
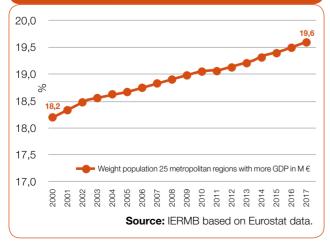
After seeing the high concentration of innovation in the main European metropolitan regions, the evolution for the period 2000-2015[9] of European patents in Catalonia is analyzed from

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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.

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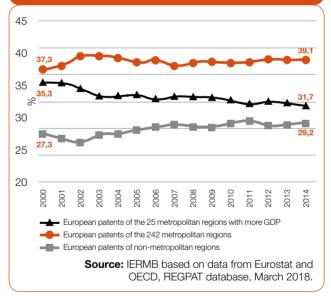
Graph 3. Weight on the EU-28 of the population of the 25 metropolitan regions with more GDP in millions of Euros, 2000-2017

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.

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-

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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.

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

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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 percent-

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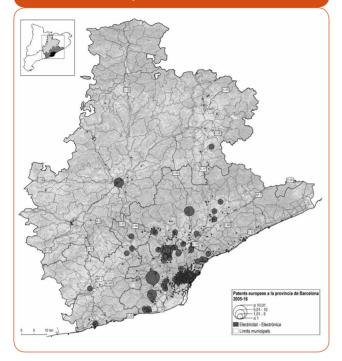
In order to quantitatively analyze the technological pattern of the innovation made in Barcelona, it is possible to analyze in more detail up to 35 technological fields grouped in the five techno-

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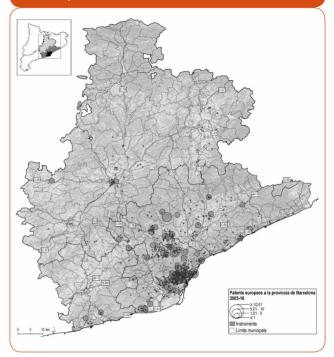
	Patents	in% on Catalonia	in% on Spain
Barcelona	1.717	32	11
Rest of AMB	1.505	28	10
AMB (36 municipalities)	3.222	60	21
RMB (164 municipalities)	4.499	84	29
Province of Barcelona	4.746	89	31
Rest of Catalonia	599	11	4
Catalonia Spain	5.345	100	35
Spain	**15.326**	**404**	**100**

Font: IERMB a partir de dades de la Worldwide Patent Statistical Database de l'OEP, primavera del 2017.
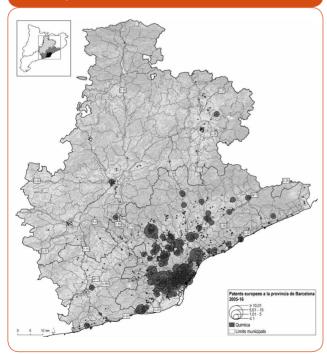
Map 2. Patent applications in the province of Barcelona, by electrical-electronics sector, by inventor's address, 2005-2016
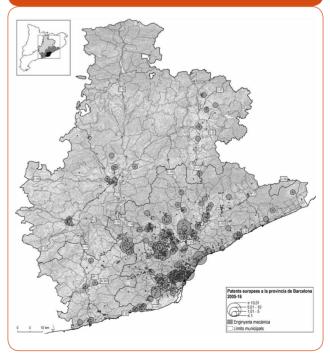
Map 3. Patent applications in the province of Barcelona, by instruments sector, by inventor's address, 2005-2016

Map 4. Patent applications in the province of Barcelona, by chemical sector, by inventor's address, 2005-2016
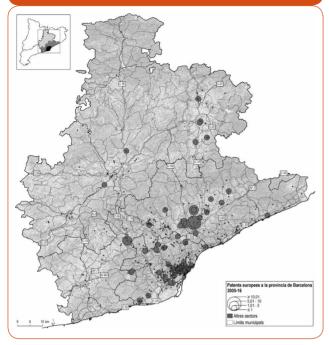
Map 5. Patent applications in the province of Barcelona, by mechanical engineering sector, by inventor's address, 2005-2016

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

Patents europees a la província de Barcelona
2005-16
≥ 10,01
5,01 - 10
1,01 - 5
≤ 1
Altres sectors
Límits municipals

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)

Exports province of Barcelona ● % variation 2005-2016

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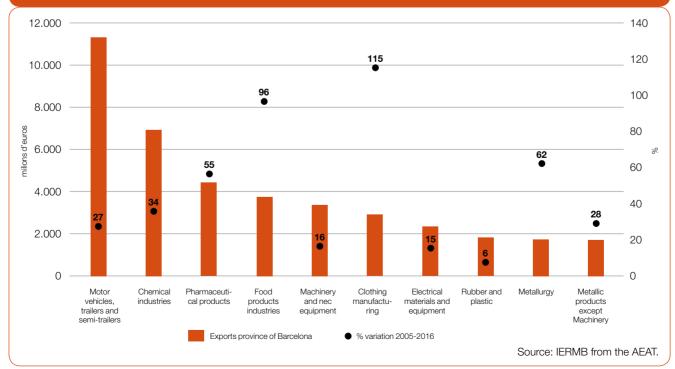
Table 5. European patents applications in the province of Barcelona according to the technological profile and inventor's address, total and percentage of the total of the province of Barcelona, 2005-2016

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,
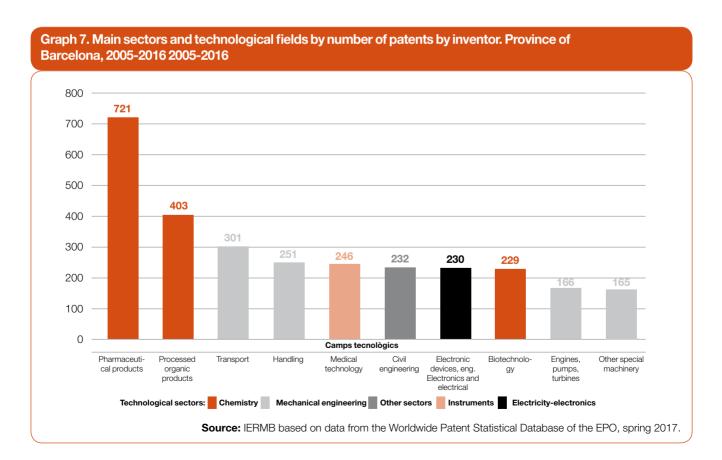
therefore, they are interested in obtaining protection also in international markets. Thus, it is interesting to analyze what relationship is established between the main technological sectors by number of patents applications and the main export sectors, in this case the province of Barcelona.

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

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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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MARSHALLIAN
INDUSTRIAL DISTRICTS AND INNOVATION IN SPAIN: 1991-2015[1]

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The debate on innovation is a complex and stimulating topic. Throughout the twentieth century it became an essential mantra (Godin, 2015) not only for its relationship with economic growth and social changes, but also with welfare, the latter being the most important.

Innovation is a multidimensional phenomenon. As such, there are many theories that explain it and the ways to measure it. In this article, we have focused on innovation as a social phenomenon and –by extension– geographical, and related to development in a broad sense. From this perspective, the unit of analysis to study innovation is not the firm, the corporation, the university or the research centre, but the place. A place (of living) is a determined and circumscribed part of the territory where a human group lives and where the economic activities with which it makes its living are localized; where the majority of everyday social relationships are established and people seek the satisfaction of their need for social integration.

In the research on innovation and territory, contrast between diversity/specialization and between cities/manufacturing places has been proposed, and often a supply-oriented innovation that assumes demand as given (see, for example, Florida, Adler and Mellander, 2017).

This article provides a different perspective. Innovation is generated not only in cities, but in other types of places, such as Marshallian industrial districts (MIDs). In our analytical framework, cities and MIDs are types of LPSs that shape the national economy. In this regard, it is noteworthy that the empirical analysis of socially and economically complex places, such as Barcelona in Spain, highlighted that cities and MIDs can integrate to form a metropolitan area (see Trullén and Boix, 2017, Aguilera and Galletto, 2018).

Notably, the article investigates the possibility that MIDs are more efficient in producing innovation than other types of LPSs, and how their innovative efficiency has evolved over time. With this goal in mind, the notion of district effect in innovation (iMID-effect) is introduced, and an innovation analysis on Spanish MIDs over a period of 25 years (1991-2015) is carried out.

The article has four sections. After the introduction, section 2 sets up the concepts of MID and iMID-effect. Section 3 explains the methodology, the data used, and the results of the analysis for the Spanish economy. Section 4 gives the conclusions.

2. iMID-effect and technological innovation

2.1. Marshallian industrial districts (MIDs)

Becattini (1989, p. 29) defines the MID as «a socioterritorial entity which is characterized by the active presence of both a community of people and a population of firms». The MID is a new approach to economic change (Becattini, 2000), which is based on the fact that economic change cannot be understood outside a specific place where the community of people and the population of firms are mutually embedded and where the economic and social forces confront each other and cooperate (Sforzi and Boix, 2015, 2018). In this view, the unit of analysis shifts from the firm or the sector to the place, which can be empirically approached by a geography of local production systems (LPSs). The mapping of local labour systems (LLSs) fits the geographical definition of LPSs (Sforzi, 2012).

MIDs have been identified as a widespread phenomenon in industrialized countries (Becattini, Bellandi and De Propris, 2009), with an outstanding quantitative importance in Italy and Spain.

2.2. District effect and static district effect

The notion of district effect was coined by Signorini (1994) to explain the high efficiency rates of the firms located in MIDs. Dei Ottati (2006, p. 74) defines the district effect as the «competitive advantages derived from a strongly related set of economies external to the individual firms but internal to the district».

The empirical investigation of the district effect focused initially on the static economic effects, that is, the effects on costs-productivity and exports-comparative advantages. Boix and Galletto (2009) and Galletto and Boix (2014) carried out a comprehensive review of this bibliography. They concluded that, in general, the results provide evidence of the district effect in the form of increased productivity, increase of efficiency, export quota, export probability or comparative advantages.

2.3. Dynamic district effect: the iMID-effect

Research on the dynamic district effect, linked to MIDs' capacity for innovation, is the most recent line of research on district effect.

Cainelli and De Liso (2005, p. 254) argued that the causes for which this line of research has long remained in the early stages

are partly explained by the literature on MIDs, which considers external economies affecting the firm-performance associated with low levels of innovation, and partly are due to the difficulty of getting geo-referenced microdata on innovation.

The first statement is controversial, since members of the Florence school (Becattini, 1991 and 2001, Bellandi 1989 and 1992) and the school of Modena (Brusco, 1975, Russo, 1986) emphasized the MID's innovative capacity. Although it is equally true that other authors continue to have a negative opinion about the innovative capacity of MIDs, because these are environments of small and medium-sized enterprises (SMEs). But what does the empirical evidence suggest?

Leoncini and Lotti (2004) showed that district firms are more likely to patent, despite the fact that the probability of carrying out research and development (R&D) is lower than for firms located outside the MIDs. They came to this conclusion using survey data from an Italian region with a high density of MIDs (Emilia-Romagna). Muscio (2006) obtained the same amount of empirical evidence proving that the probability of firms introducing innovation is higher for the firms located in the MIDs. Santarelli (2004), using data from European patents, found inconclusive evidence about the existence of a district effect.

On the other hand, Cainelli and De Liso (2005) proved that district firms implementing product innovations perform better than firms located outside the MIDs; and that firms located in the MIDs innovating their product perform better than those innovating their processes.

Boix and Galletto (2009) introduced the notion of district effect in innovation (or iMID-effect) when they investigated the innovative capacity of MIDs with regard to the rest of Spain's LPS. Their results made known that Spain's MIDs showed on average an innovative intensity (patents per million of employees) 40% higher than the Spanish average. Then, Boix and Trullén (2010) disaggregated the territorial and sectorial component of the effect. They concluded that the effect was more robust with regard to the territorial component than to the sectorial one and, therefore, that the greatest innovative intensity of the MIDs was due to their socioeconomic organization more than to their sectorial specialization. Later, Galletto and Boix (2014) and Boix, Galletto and Sforzi (2018) have shown that the district effect on innovation occurs even when considering the potential value or quality of patents.

> *MIDs are more efficient in producing innovation, and how their innovative efficiency has evolved over time*

2.4. The engines of innovation in MIDs: the sources of the iMID-effect

The literature on MIDs highlighted that the district model contributes to maintain the innovative capacity of firms and supports the adoption of innovations. From a theoretical point of view, there are two points that can explain the iMID-effect.

1. The existence of "decentralized (or diffused) industrial creativity" (Becattini, 1991 and 2001, Bellandi, 1989). Basically, this idea is similar to flexible integration process: if the innovation can be carried out in large firms and in a planned manner, the innovative process can also be subdivided into multiple small-interconnected "firms of phase" in an unplanned way. Decentralized industrial creativity is reinforced by a decentralized model of absorption of new knowledge, which in turn circulates as a self-regulating result of the interactions between local firms. It is a result obtained more from search strategies and multiple cooperative interactions between firms than from planned and deliberate efforts to carry out R&D activities, as proposed in a typical linear innovation model.

These interactions – and the related feedback – occur throughout the supply chain and the different inter-firm networks of a MID, where firms cooperate in the manufacture of different products, product components or production phases. When existing knowledge is combined within a firm, a new knowledge is generated that can be translated into either a simple imitation or a variant of the original innovation. In this regard, marginal changes occur through different sources: design activities, learning processes in manufacturing, interactions with customers and suppliers, re-use and re-working of pre-existing external knowledge. This decentralized model of knowledge absorption conceives the innovative process as a circular process with feedback and information connections between the wants of the market and the processes of design, manufacturing and research of new solutions, that is, in the form of a cognitive spiral (Becattini, 2001). This behaviour is associated with Marshallian external economies (labour markets, subsidiary industries – both manufacturing and business services – and shared knowledge

among firms specialized in different phases of the same production process).

2. The iMID-effect can also be explained by the joint functioning of the theory of differentiated knowledge bases and that of modes of innovation. Asheim and Parrilli (2012) differentiate between three types of knowledge base: analytical (science-based), synthetic (engineering-based) and symbolic (creativity-based). These types of mixed tacit and codified knowledge are intertwined with two modes of innovation: STI and DUI modes.

The STI mode of innovation (Science, Technology and Innovation) is associated with the production of analytical knowledge generated in deductive and formal models of science and technology, and is highly codified. An example of this mode is the linear model of innovation, based on science, R&D and the generation of disruptive innovations. The pharmaceutical industry is the typical example of this model.

The DUI mode of innovation (Doing, Using and Interacting), more associated with the synthetic and symbolic knowledge, is based on the generation of innovation through the learning and the resolution of problems in the daily work development, because workers (entrepreneurs and their employees) have to meet continuous changes and interact with customers, which forces them to face new problems and solve them. The search for solutions to these problems strengthens the skills and knowledge of workers and makes extensive use of tacit and often localized knowledge. The DUI innovation mode is customer-driven and mainly produces incremental innovations, although in practice it is also capable of producing radical innovations. Examples of this model are numerous in the mechanical, ceramic or furniture industry.

The innovative process in MIDs share similarities with the DUI mode. Therefore, it implies knowledge that can be largely tacit and specialized in its context of development and application. This mode brings back the importance of the experience presented in the learning-by-doing, by-using and by-interacting models formulated by Arrow (1962) and Rosenberg (1982).

Both issues, decentralized creativity and synthetic/symbolic knowledge, are intertwined (Bellandi, 1989) to such an extent that marginal modifications serve to meet and increase market demand. The existence of a broader market increases the profitability resulting from a larger division of labour between firms, since this specialization increases economies of scale and scope. During this process of growth, some district firms

generate new knowledge, introducing radical innovations. When these innovations spread throughout the MID, they make it more competitive. Furthermore, there are MIDs that experienced a growth in which continuous learning has led to a process of intense product differentiation, powering the competitiveness of their firms (Belussi 2009, p. 470). The working of these processes makes the MID show a positive innovative differential (i.e., a iMID-effect) with regard to other types of LPS.

Boix and Galletto (2009), Boix and Trullén (2010), Galletto and Boix (2014) and Boix, Galletto and Sforzi (2018) have modelled the determinants of the iMID-effect in Spain during the period 2001-2005 using patent data and a categorization of LPSs based on the 2001 census. The results show that the MIDs generate almost 30% of the patents of the Spanish economy and that, despite the lower average expenditure in R&D, they have an innovative intensity above the Spanish average. Although public and private spending has a positive effect on innovation for MIDs, the high intensity of innovation is mainly associated with external economies of specialization (Marshallian), and even more than with economies of diversity and variety or with variables related to formal education.

3. Empirical evidence on MIDs and technological innovation in the Spanish economy: 1991-2015
3.1. Methodology and data
To follow the evolution of the iMID-effect in the Spanish economy, the current study uses the indicators based on averages as proposed in Boix and Galletto (2009). Innovative intensity is measured as the number of patents per million employees in a given period. Data are indexed on the average of Spain, so that they show the differential with regard to the Spanish average in each established period.

Technological innovation is based on the registers of Spanish patents and utility models (Spanish Patent and Trademark Office), European patents (European Patent Office) and global patents (Patent Cooperation Treaty). Data are geo-localized from the inventor's mailing address (alternatively, the applicant's address is used when the inventor's address is not available and there is no way to assign it). The geo-localization allows grouping the data by LPS. The patent is assigned to the year in which the registration period has been requested since it is considered the closest to the year of invention. The current study covers a pe-

riod of 25 years, from 1991 to 2015. For this period, the database incorporates around 130,000 registers.[2]

Galletto and Boix (2014) proposed a method to weigh patents based on the potential value of the type to which they belong (i.e., Spanish, European and global patents). The use of this procedure allows the patents to be weighed for their potential quality and provides a complementary indicator.

The current analysis uses two series. The first one uses annual data, and allows the sensitivity to the effects of the economic cycle to be observed. The second uses three five-year data cuts (1991-1995, 2001-2005, 2011-2015). Data aggregation by groups of years is quite usual in innovation studies and aims to eliminate the effects of random annual fluctuations (see Aguilera and Galletto, 2018).
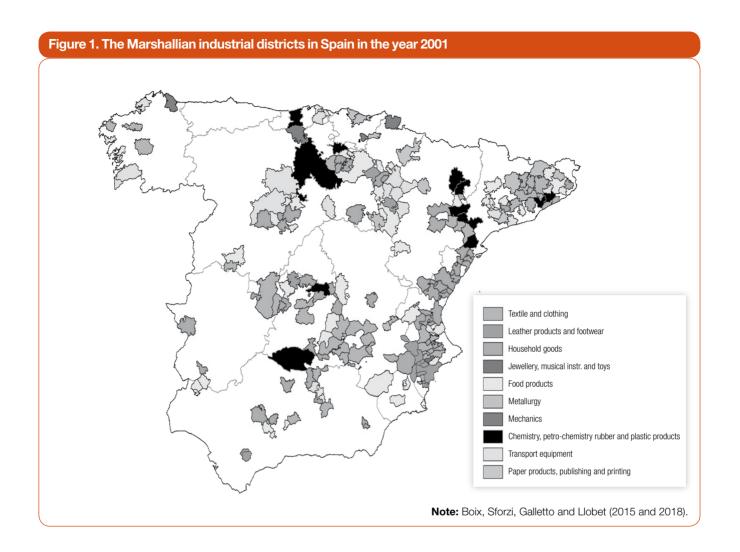
The mapping of MIDs and other types of LPS can be updated every ten years, at census. This fact allows mappings that change during the period under study (i.e., the 1991, 2001 and 2011 maps) to be used or that a map at a given time is selected. For the current analysis, we opted for the mapping of 2001 – the intermediate year of the period under study – to simplify the measuring of the innovative intensity of the Spanish MIDs during the period 1991-2015.

3.2. MID and typology of LPSs
The standard procedure for the identification of MIDs is known as Sforzi-Istat, and it is explained in detail in Sforzi (2009)[3]. Boix and Galletto pioneered in Spain this methodology (2006 and 2009), with revisions and updates (Galletto and Boix, 2014). The last update can be found in Boix, Sforzi, Galletto and Llobet (2015 and 2018). They define the 2001 and 2011 mapping of MIDs. An extension of the procedure (Boix and Galletto, 2009) allowed the rest of LPS – those that are not MIDs – to be classified based on their specialization in agriculture and primary activities, mining, construction activities, large-scale manufacturing and other manufacturing mixed

2 See Boix and Galletto (2009) and, for more details, the recent study by Aguilera and Galletto (2018).
3 The methodology has two stages (Sforzi, 2009). The first stage identifies local labour systems (LLSs) using data on inter-municipal daily journeys to work. The second stage identifies the LLSs with district characteristics, that is LLSs with a main specialization in manufacturing (among those manufacturing, of business services and consumer services) and the dominance of small and medium-sized enterprises (SMEs) both in the LPS as a whole and in its main manufacturing industry (what defines its specialization).

Figure 1. The Marshallian industrial districts in Spain in the year 2001

Legend:
- Textile and clothing
- Leather products and footwear
- Household goods
- Jewellery, musical instr. and toys
- Food products
- Metallurgy
- Mechanics
- Chemistry, petro-chemistry rubber and plastic products
- Transport equipment
- Paper products, publishing and printing

Note: Boix, Sforzi, Galletto and Llobet (2015 and 2018).

sizes of firm, business services, consumer services, social services and traditional services.

The 2001 mapping of Spain by Boix, Sforzi, Galletto and Llobet (2015 and 2018) identified 677 LPSs, of which 215 had MID characteristics (figure 1). In 2001 MIDs accounted for 24% of the Spanish population (9.90 million inhabitants), 24.9% of the total employment (4.06 million employed persons) and 38.2% of the employment in manufacturing (1,088,582 employed). 70.7% of MIDs were specialized in household goods (26%), food products (22.8%) or textiles and clothing (21.9%). These three main industries of specialization also accounted for 60.9% of employment in the MIDs' manufacturing industry and 59.1% of that in the main industries.

3.3. Results: do MIDs show a better behaviour in the generation of technological innovation than the Spanish average?

Between 1991 and 2015, MIDs generated an average of 1,600 patents per year. During these 25 years they accumulated around 40,000 innovation patents, equivalent to 30% of Spanish patents, which is a remarkable result.

Have MIDs shown a better differential behaviour generating technological innovation than the Spanish average? The answer is positive. We can establish some stylized facts from Figure 2 and Table 1.

1. During the period 1991-2015, MIDs generated an amount of innovations per million employees 27% higher than the Spanish average (figure 2). In addition, the number weighted by the potential quality of the patents (see Galletto and Boix, 2014, Boix, Galletto

and Sforzi, 2018) shows that the innovative intensity of MIDs remains on average 13% above the Spanish average (figure 2).

2. The innovative differential of MIDs is more sensitive to the economic cycle than the Spanish economy as a whole (figure 2). It decreases during recessions and increases during the growth stages. This behaviour is explained by: a) the high openness of MIDs to international markets; b) the greater sensitivity of its products to fluctuations in demand; c) the high adjustment of industrial employment in Spain during recessions; and, last but not least, d) the more conservative behaviour of SMEs when registering European and international patents (the registration costs being much more expensive than those for national patents), as the weighted indicator points out.

3. LPSs of large manufacturing firms and LPSs specialized in business services[4] also show an above-average innovative intensity, as well as the other manufacturing LPSs (combining mixed sizes of firms) (table 2). In the case of the LPSs of large firms, these doubled the Spanish average in the period 1991-1995 but decreased to 49% for the period 2011-2015 (unweighted indicator).

4. The rest of the LPSs – specialized in agriculture, mining, construction, consumer, social and traditional services – show an innovative intensity remarkably lower than the Spanish national average.

4. Conclusions

In Spain, the generation of technological innovation is a highly geographically localized process. The geographical gap of innovation is not so much between places that innovate a lot (manufacturing LPSs and business services-oriented) and places that innovate little (the rest of LPSs, a part of which corresponds to low-density geographies of population and employment or specialized in other services). In fact, the results suggest that: a) a complete model, associated with the core LPSs of the metropolitan areas of Barcelona and Madrid, with strong analytical, synthetic and symbolic knowledge bases; b) a partial model represented by MIDs and non-MIDs manufacturing LPSs (some of them having characteristics of geographical cluster à la Porter),

and which show an intense synthetic knowledge base with lower analytical and symbolic knowledge bases; c) the rest of LPS, characterized by the weakness of their knowledge bases.

Theories such as decentralized creativity, differentiated knowledge bases and modes of innovation support that MIDs show a high innovative dynamic, based on territorial organization of the production process and on a differentiated and variable demand of consumers who aim at satisfying desires for variety and social distinction.

The MID is a different way to innovation, and a new approach to industrial change. The publication in 1986 in the first issue of the Revista Económica de Catalunya of the seminal article by Giacomo Becattini "From the industrial 'sector' to the industrial 'district': some remarks on conceptual foundations on industrial economics" (originally published in 1979, later re-published in Becattini, 2004), paved the way for district studies in Spain.

Within the Spanish economy, MIDs have proven to be an efficient way to organize production and generate innovation. When studies warning about the perverse effects of innovation on the destruction of employment and the polarization of income and spatial segregation begin to appear (see, for example, Florida and Gaetani, 2018), efficiency may not become the main objective. Becattini (2000) endorses the MID as a form of organizing production more compatible with equity and distribution objec-

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4 According to the revised 2001 classification, the biggest LPSs of large manufacturing firms include Barcelona, Zaragoza and Pamplona and those specialized in business services include Bilbao and Madrid. The averages have been calculated using the data aggregated by category. Therefore, the weight of Barcelona and Madrid affects the results on innovative capacity of LPSs of large manufacturing firms and business services.

Figure 2. Technological innovation (patents per million employees) in MIDs of Spain (1991-2015). Spain = 100 and ID of 2001

Note: LPS constants identified from 2001 census. Revised mapping (Boix, Sforzi, Galletto and Llobet, 2015).
Source: IERMB from 2001 census, Ministry of Employment and Social Security, OEPM, EPO Bibliographic data and PATSTAT.

Table 1. Patents and utility models per million employees in LPSs identified from 2001 census, by type of LPS, 1991-2015. Spain = 100.

Tipus de SPL/període	Innovació			Innovació ponderada per qualitat		
	1991-1995	2001-2005	2011-2015	1991-1995	2001-2005	2011-2015
Agriculture	31,3	40,2	43,0	19,6	22,1	26,5
Mining	25,5	51,8	55,2	19,6	14,7	34,3
Manufacturing	147,9	149,0	133,8	145,1	154,7	143,1
Industrial district	**122,4**	**134,8**	**122,8**	**100,0**	**117,9**	**107,8**
Large firm	200,0	174,2	148,7	241,2	221,1	197,1
Others	146,9	146,7	152,8	135,3	149,5	177,5
Construction	39,1	47,0	53,1	31,4	28,4	28,4
Services	80,2	75,4	88,7	86,3	74,7	85,3
Business services	128,1	102,3	113,1	154,9	115,8	123,5
Consumer services	46,4	47,6	38,9	43,1	40,0	29,4
Social services	69,0	74,2	87,5	60,8	67,4	87,3
Traditional services	34,6	49,9	75,1	27,5	36,8	49,0
Spain	100,0	100,0	100,0	100,0	100,0	100,0

Source: IERMB from 2001 census, Ministry of Employment and Social Security, OEPM, EPO Bibliographic data and PATSTAT

tives (see Trullén and Boix, 2017). In a sense, the MID model of production is "a capitalism with a human face" (Becattini, 2004).

Nevertheless, the relationship between different types of LPSs, innovation and inequality has not yet been analysed for the Spanish economy.

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CREATIVITY AND KNOWLEDGE: URBAN FOUNDATIONS FOR GENERATING INNOVATION

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The new competitive paradigm of economic agents is characterized by creativity and knowledge as drivers of change and development. This has led to important transformations in the productive model of business organizations and in the axis on which economic competitiveness is based. More than ever, the city as a scenario and object of innovation bears capital relevance as an explanatory variable of both the success and the conflicts associated with this change of model. Aspects such as diversity, cohesion, talent or multiculturalism contribute to generate greater creativity in the city; the channels and means available to the city to transform creativity into both business and social innovation will determine the positioning of the city in the international urban landscape.

If creativity is a crucial component in successful economies and societies, it is interesting to analyze the mechanisms through which it becomes clear and it is used and transformed into innovation in the city. This article wants to reflect on how cities respond to the need to accommodate creativity to encourage innovative processes by the different agents that make it up.

First, this paper reviews the role of the city in the globalized world. Next, it outlines the relationship between the urban phenomenon, creativity and innovation and presents some arguments on the role played by the creative industries in the city and its needs. Next, it analyzes the city as a driver of innovation and the setting of new production practices. Finally, it mentions the main future challenges associated with urban environments that stimulate innovation.

The role of the city in the new international economic order

The 21st century is characterized by the generalization of the context of economic, social and cultural globalization, which began in the last century as a result of the appearance and spreading of new technologies. This phenomenon is currently accompanied by persistent and worrying global imbalances; among others, the maintenance of important economic inequalities of the population or the exhaustion or waste of natural resources and the recent incorporation of high levels of international political uncertainty.

Supranational bodies such as the UN or the European Union

try to counteract the consequences inherent to the system through global objectives. These objectives are, for example, improving in indicators of social, environmental or economic sustainability or a better redistribution of resources. However, even if the objectives are globally defined, the neuralgic centre of development of actions and programs has moved from the international, national or regional scope to the local urban environment. The best indicators associated to economic development -such as the negative effects it causes like poverty or the lack of energy resources- are concentrated there. The cities, their areas of influence and their interrelationship are currently the main units of analysis to understand and correct or stimulate both the demands and the consequences of economic growth.

In this scenario, the competitive positioning of the cities and, therefore, of the actors that make them up, is determined, among others, by their own particularities and by the objectives that they intend to achieve. The singularities are defined both by the trajectory in their economic development, the resources (natural and infrastructural) they have, the skills or competences of the actors that comprise them and a specific institutional fabric (Musterd and Gritsai, 2012). Given the different opportunities presented by local capacities, the objectives and behaviour of economic agents have undergone substantial changes: the economic competitiveness of the past based on Price - and therefore on the resources that allow producing at a lower cost- has created a new competitiveness based on creativity, knowledge, quality of life and innovation (Best, 1990).

The changes in the drivers and objectives of economic development shifted the order of importance of local features to explain the location of productive activity. Thus, the city has become an attractive and competitive environment: from investments in classic factors such as infrastructure, telecommunications or mobility through the spatial concentration of companies to generate positive external effects or spillovers to the most recent theories of attraction of talent or theories in which the trajectory, the agents and the existing resources in the city are nurtured and improved to achieve bigger growth.[1]

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1 For a good summary of the different approaches, see S. Musterd and A. Murie, A. (eds.) (2010). Making Competitive Cities. Wiley. Blackwell (360 p.).

The scenario that draws up this new competitiveness causes the main agents of the city (companies, institutions, population) to concentrate their efforts in the production (and application) of innovation. Often, the objectives behind this search differ: while companies require innovation in both process and product to be competitive and stay in the market, dynamic and changing with fast paced, institutions and citizens need innovation to create more flexible and close governance structures, reduce the imbalances generated by the same growth or facilitate diverse and multicultural coexistence.

Thus, the need to produce innovation for a series of urban agents makes creativity, a source of inspiration and driver for the generation of disruption, a key element for the unleashing and acceleration of innovative processes. This way, creativity becomes a crucial component for successful societies and economies based on innovation. While in the past cities sought their competitiveness based primarily on the creation of a critical mass of business capable of producing and exporting with reasonable costs and a decent quality, cities nowadays diversify the search for competitiveness based on not only economic objectives but also social, cultural and environmental, understanding creativity and consequent innovation as an essential ingredient in this change of orientation that defines their competitive advantage (Neely and Hill, 1998). Thus, the innovative dynamics of the agents of the city are the main architect for international urban competitiveness: the measurement and gradation of this competitiveness becomes much more complex given the confluence of different dimensions -the economic, social, cultural and institutional-, which do not always coincide in the objectives.

This article reflects on the ways in which cities respond to the need to accommodate creativity with the aim of encouraging innovative processes on the part of the different agents that make it up.

Creativity and innovation in the urban context: the 'creative milieu'

There is a certain difficulty in defining and characterizing what is understood by creativity, what are its determining factors, what types can be defined and how it acts as an articulation of innovation. Each possible definition or classification of creativity has consequences on the characterization of the innovation it produces: from the differences between scientific creativity -non-replicable and looking to be superior to past dis-

"Now more than ever, creativity becomes an essential element for successful societies and economies based on innovation"

coveries- and artistic creativity -inspiring replication and recreation (Legrenzi, 2005) to destructive creativity as a catalyst and driver of change and economic progress (Schumpeter, 1942)[2] and creative disruption as truly departing from the norm, from the existing one, exploring new horizons and defining new approaches (Dru, 1996).Creativity becomes the central lever of innovation for all relevant areas of society (economy, institutional and political framework and value structure); the meaning and sense that derive from the creative and cultural field are today the central element of the new global competitiveness.

Deriving from the relative abstraction of the creative concept, a series of proposals have been articulated that approach the concept with more or less success: for example, creative industries, creative and talented people or creative cities. Regardless of the acceptance, there is a coincidence in the need to study creativity in the social and spatial context that occurs as a result of interaction processes (Csikszentmihalyi, 1988, Amabile, 1996, and Sternberg and Lubart, 1991, among others). Thus, to speak of the innovative phenomenon and its relation to creativity requires coordinates of time and space and a set of specifically territorial elements to be able to find out the behaviour and the determining factors of this binomial in the strategic response offered by contemporary economics to the challenges of competitiveness and globalization (Pratt and Jefcutt, 2009).

Both the concentration of the population in urban areas[3] and the structural change produced in the economic activities there make cities the preferred geographic space with the most important innovative dynamics that affect economic

progress and the welfare of citizens. The resilience and the urban adaptation to this new context determine the competitive positioning of the city and the agents that make it up. In fact, companies and organizations have perceived for decades the need to adapt to this dynamic and changing environment, creating the mechanisms and structures necessary to be competitive in this context. The parameters that fundamentally determine this transformation are based on the need for organizational flexibility, a high dependence on production ecosystems and permanent innovation as a key element in any survival process. It is precisely in the places where innovation is produced and used, where productive systems have experienced a greater change: although creativity is understood as a fundamental ingredient of any innovation, the consequences of its application are currently much more breaking or disruptive.

One of the dilemmas that has been studied in depth with respect to the relative concentration of companies and the production of positive externalities among them highlights which must be the characteristics of the companies that agglomerate in a territory; on the one hand, it is considered that a high concentration of companies of a particular industry in a specific geographical environment facilitates the exchange of knowledge between them (Glaeser et al., 1992). On the other hand, authors such as Jane Jacobs consider that it is precisely the exchange of complementary knowledge between companies and economic agents that facilitates a production of greater innovative knowledge (Jacobs, 1969). In this sense the concept of creative milieu, beyond the term creative city popularized by Charles Landry or Richard Florida, holds onto the importance of the transmission and storage of information and knowledge among various agents creating a series of synergies and externalities between them.

The existence of an interdependent network of producers that at the same time presents multiple interactions between companies and workers, the high product differentiation and, especially, the use of creativity as a key resource in their development is essential for the development of synergies that increase the knowledge and innovation between sectors (Hall, 2000, Scott, 2006). Based on the concept of relative variety, Lazzeretti (2009) defends the agglomeration of creative industries due to cross-fertilization, new combinations of knowledge and geographical proximity. The same concept (relative variety) increases innovation rates in local systems due to the

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2 Processes of industrial mutation that constantly revolutionize the economic structure from the inside, constantly destroy the previous one and constantly build a new one.
3 In 2017, approximately 55% of the world population lived in urban settlements. Around 2030, urban areas will receive more than 60% of the world population and one in every three people will live in cities with more than half a million inhabitants (UN, 2017).

external effects (spillover) that the creative industries generate in other sectors (Lazzeretti et al., 2012).

Considering creativity as an infinite resource (Foord, 2008), some arguments promote economic development based on business strategies based on their capacity for innovation as a result of using the creative capacity of the environment. Thus, almost independently of the local resources that a certain city possesses, the mobilization of existing creativity can transform their economies and communities. The question is how to approach the connection between the existing creativity in the territory and the innovation produced in companies, institutions and markets in the urban environment.

In this sense, different disciplines and geographical contexts studied which are the mechanisms through which it is possible to transfer the creative resource in specific innovative applications, whether product or process. In particular, Cohendet et al. (2012) investigate the intrinsic anatomy of the so-called creative city, examining the mechanisms that link the creative fertile fabric of the city (underground), in charge of exploring new ideas, new models or theories, with the innovative capacity of companies, institutions or the markets (uppground). These mechanisms are designated by a set of spaces, events, places and projects (middleground) that facilitate the transfer of ideas, inspiration and creative knowledge in companies, institutions and markets. For example, the Mobile World Congress held in Barcelona together with the recognition of the city as Mobile World Capital since 2012, has many features (such as the celebration of the 4YFN) that position it as an instrument that allows dialogue between the creativity and business innovation, as a middleground device. Thus, cities that invest in the development of devices that act as a connecting bridge between one ground and the other will be better placed to compete in terms of innovation and take advantage of the synergies generated by creativity.

In the city, there are different forms of economic innovation such as investing in new sectors or economic activities linked to the symbolic economy or the proliferation of creative industries, together with social innovation based on emerging governance processes deposited in new forms of interrelation between economic, political and social agents. Therefore, innovations make up competitiveness and social cohesion in an organic way and contribute not only to improving economic competitiveness but also to increasing employment and gen-

> ## *The European Commission (2012) considered the cultural and creative industries are the drivers of growth and creation of jobs*

erating social cohesion. Also the answers to the main challenges of society, such as climate change or sustainable development, lay in the capacity of cities to stimulate and provide resources for social innovation. In particular they lay in their capacity of helping towards the contribution of CCIs in developing the combination of skills around creativity and entrepreneurship, critical thinking, taking risks and the necessary commitment to competitiveness in the knowledge society.

"The European Commission (2012) considered that the cultural and creative industries are the drivers of growth and creation of jobs"

The cultural and creative industries (CCI) in the territory: measurement and impact

Necessarily, the evaluation of the city in creative terms often happens to take into account the existence of indicators associated with creative employment and creative industries. It mainly refers to the number of companies and workers, the measurement of their economic production in terms of gross added value or exports, as well as the manifestation of specific policies that aim to promote creative initiatives in the territory (Kooijman and Romein, 2007).

Among others, the EY study (2015) on cultural and creative industries calculated that in 2013 this sector produced 3% of world GDP. It created 29.5 million jobs and generated an activity worth 2,250 million dollars. Transferring the large figures of the creative sectors to the territory, the report promoted by the European Commission[4] (2017) The Cultural and Creative Cities Monitor indicates that, comparing those cities consid-

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4 For statistical and management purposes, the European Commission considers that the cultural and creative sectors "... include all sectors in which activities are based on cultural values and/or artistic and other forms of creative expression. They include architecture, archives, libraries and museums, artistic crafts, audiovisual (including film, television, video games and multimedia), tangible and intangible cultural heritage, design, festivals, music, literature, performing arts, publishing, radio and visual arts "(European Commission , 2017, page 9).

ered in the report as creative to other cities that are not, with a minimum of 50,000 inhabitants, creative cities produce more jobs (19% more), employ more young people (8% more), have more students in higher education (73% more), more highly qualified people per capita live there (15% more) and receive more immigrants (22% more in the case of those coming from the European Union and 26% more in the case of those coming from outside the European Union).

The European Commission (2012) considered that cultural and creative industries are the drivers of growth and creation of jobs and proposed, already in 2012, a strategy to promote and help these industries (COM (2012) 537 final) based on the identification and the mobilization of the existing creative and cultural resources of a given territory and a tailored design of support policies regardless of the level of government, be it national, regional or local, bringing together in the form of multi-faceted partnerships both between departments (culture, education, planning, tourism, etc.) and between key relevant agents, public and private.

The weight or relevance of the creative and cultural industries (CCI) represents a good approximation to the creative abilities of the city and its innovative capacity. Creativity directly impacts sectors that are not strictly creative, such as tourism, while at the same time it is integrated into the value chain of other sectors such as fashion, design or advertising. The CCIs are catalysts of innovation, since they are in a strategic position, at the intersection between the artistic, business, technological, cultural and creative sectors, to trigger external effects (spillovers) both for creative sectors as in other industries and sectors which are not creative.[5] In fact, innovation is driven more and more by non-technological factors, such as creativity or design, and by the emergence of new organizational processes or business models. Thus, the so-called creative ecosystems help the contact and the transmission of experience and vision among different agents and sectors.

In short, CCIs generate jobs, economic growth and wealth and are often associated to social inclusion, environmental sustainability and cultural diversity. Also, CCIs encourage the emergence of creative crossovers either through products and services or as a tool for generating new ideas. Therefore, it is vital to understand how these ICCs are characterized and function in order to provide the necessary instruments to reinforce them at local scale without losing sight of the fact that CCIs are increasingly part of global production networks, beyond the thresholds defined by the local development.[6]

New practices and formats around creativity and innovation

CCIs are basically a set of heterogeneous and diverse industries where skills and abilities along with talent play an essential role. The application of new technologies, an important degree of innovation in products or services and the relevance of symbolic and experimental factors in the creation of ideas of products characterize most of the CCIs (HKU, 2010). Certain ambiguities regarding the ways of operating and producing are detected in the CCIs due to the difficult generalization that occurs when talking about these activities and the complexity, volatility and unpredictability of their markets. On the other hand, under the generic meaning of CCI you can find some large companies such as Planeta or Cirque Soleil and many small and medium companies such as Tigre de Papel, El Adelanto or Circ Cric. The business dimension in many cases conditions the contribution to GDP and the export capacity of the company. A common trait in all cases is the fact that innovation is essential for their survival.

To these basic features we must add the generalization of the projectification of the economy or operating by project or challenge, a characteristic very common in CCIs as well as in engineering that extends progressively to other economic sectors. The collaboration and interaction between agents can follow different patterns but in all cases the growing phenomenon of disintermediation is easily discernible. Specific purposes and organizations created ad hoc are the way in which a good part of these new business relationships are based. Instead of value chains and R + D departments, knowledge is produced, transferred, and applied through projects that con-

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5 See the report by Tom Fleming Creative Consultancy in 2015, Cultural and creative spillovers in Europe: a preliminary evidence review at the request of the European Research Partnership. in http://ccspillovers.wikispaces.com/.

6 The European Project (822778) CICERONE (2019-2022), led by R. Kloosterman of the University of Amsterdam –and where this article's author coordinates the team of the University of Barcelona as a Spanish partner- has as a main objective to find out these local / global ICC interrelations using the approach of GNP (global networks of production) as a heuristic and comprehensive framework that is sensitive to the multifaceted characteristics of local production of ICCs

stitute an area of temporary organization in which knowledge is combined from a variety of sources to do specific tasks (Grabher, 2002). To this end, the variables that make up project ecologies are essential (Grabher, 2004): among others, the diversity of existing knowledge, relational networks based on trust and reputation, the characteristics of the environment in which they are developed, available resources such as financial or existing knowledge transfer mechanisms. In other words, business ecosystems are defined as a combination or set of companies (large and small) from different industries that aim to work with each other because they have economic interests, capabilities or complementary knowledge that are generally based on technological or business interdependencies (Tukiainen, Lindell and Burström, 2014).

The city, as the framework where the project ecologies are developed and as an intricate ecosystem where they are accommodated from the production of author fashion to the publication on paper of best sellers, becomes capital to facilitate the necessary synergies produced around the business challenges and in particular the running of the CCI. This way, the city becomes an innovation collaborative platform where "…cities should establish active dialogue with their citizens, and private and public sectors actors to co-create, develop, test, and offer service innovations that utilize diverse sets of platforms such as living labs" (Tukiainen et al., 2015, p.16).

The reduced size of the CCI requires alternatives to traditional production models to achieve sustainable growth trajectories. Many of these models are based on transparency, since this is necessary to support new forms of communication between companies, and knowledge and shared language to make collaboration possible. The relevance of networks among workers and the forms of crossover cooperation in their activities require certain spatial contexts that allow carrying out new forms of relationship between actors (Pareja-Eastaway and Pradel, 2017). In short, the project ecologies and their settlement in the city explain to a large extent the capacities of each city to accommodate the growth and development of the new CCI.

Creation spaces and communities of practice

The so-called spaces of creation that prompt forms of open innovation (Chesbrough, 2003) become a possible axis of analysis to understand how creativity works and its transformation into innovation. Creation spaces are defined in a broad sense, including different typologies:

● Formal, such as the university, and informal such as, for example, communities of practice developed around certain business or social challenges.

● Public, such as, for example, arts factories in cities such as Barcelona or Bilbao and private ones, as for instance MOB or the Institute of Next in Barcelona.

● Ephemeral, with a limited duration in time such as festivals like the Feria de Tàrrega and permanent, such as co working spaces installed throughout the local geography.

● Mono-sector, dedicated exclusively to a sector or related companies such as the Beauty Cluster Barcelona and crossover, which offer spaces for different disciplines, connected or not, such as some of the Art Factories in Barcelona.

● Traditional, such as R + D + I and incipient centres, for instance on-line platforms such as Màtics,[7] used to share knowledge and deal with challenges from different perspectives or communities created around a specific local challenge such as Poblenou Urban District.

The cities receive these spaces in a lesser or greater extent depending, among others, on their own trajectory and the agents and institutions that make it up. Creation spaces are often linked to concepts such as collaboration, participation, co-creation, open innovation, co-design, coworking … Currently, this terminology appears regularly on any reflection in business organizations, the Administration or in any social agency. In fact, in 2014 the Research Group on Collaborative Spaces[8] (RGCS, Research Group in collaboration Spaces) was created as an independent network and think tank that brings together mainly academics in the fields of humanities and social sciences (management, sociology, economics, anthropology ...) with the aim of analyzing "… new work practices (e.g. the emergence of collaborative entrepreneurship, self-financing, slashers, employment-entrepreneurship hybridization, telework, remote work, mobile work, DIY, DIT, makers, open Innovation, open knowledge, corporate hacking…) and workplace transformations (e.g. open spaces, coworking spaces, mobile work, digital nomads, corporate fab labs, fab cities…) in the context of the sharing and peer-to-peer econ-

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7 http://maticsbarcelona.net/.
8 https://collaborativespacesstudy.wordpress.com/a-propos/.

"Innovation becomes the most important ingredient to participate in the new scenario of international competitiveness"

omy. Our network explores in particular collaborative practices, collaborative spaces, collaborative communities and collaborative movements (e.g. coworkers, makers and hackers) and how they transform or make visible (new) work practices."(RGCS website).

Beyond the individual genius, creativity is understood as the result of a process of interaction between individuals where the collaboration between agents can follow different patterns and methodologies. Among others, the so-called communities of practice (Lindkvist, 2005) are concrete examples of long-term partnerships that deal with the transfer and share of knowledge based on relationships of reciprocity and shared knowledge.[9]

The notion of a community of practice has become a very influential way of conceptualizing the way subunits or groups within companies or organizations operate. These collaboration strategies can undoubtedly be identified in many business strategies in the creative sectors. A small-scale temporary application of this methodology in an innovative teaching context is the Summer School on Management of Creativity in an Innovation Society led by the Mosaic team of the HEC-Montreal and the Universitat de Barcelona.[10] In this school, Innovation professionals in different sectors, artists, master students and academics work for two weeks around challenges that certain companies wanted to solve or approach. The different skills or expertise along with the innovative experiences of organizations in both Montreal and Barcelona make the School a unique example of creating complicities, transfer of knowledge, networking and innovation between very different agents.

Final Reflection

In recent decades, the reference coordinates for companies have varied, as have the essential ingredients for the proper running of cities. Innovation as a result of creative processes becomes the most important ingredient to participate in the new scenario of international competitiveness. The accelerated dynamics of transformation caused by innovation in all possible areas of the urban scale act as a permanent challenge for economic and social agents.

The business ecosystems typical of innovative projects associated with current challenges are rooted in the intrinsic characteristics of the city. The ability of cities to compete in this new scenario will be determined by their competence when it comes to:
- generating joint work structures from networks based on trust, mutual respect and reputation;

- promoting infrastructures that accommodate spaces for creation and collaboration between agents;

- using the city as a living lab to test innovation;

- stimulate the innovative potential of people, companies and institutions by designing programs and actions that facilitate learning and exchange based on creativity;

- facilitating hybridization processes between creative and non-creative sectors;

- identifying the key barriers for the development of creative knowledge such as finance;

- taking advantage of the potential of universities as centres for creating innovation and attracting and producing talent;

- promoting structures that are adaptable to the stimulus of business innovation through business incubators or accelerators;

- and guaranteeing a social impact of advances in innovation at city level.

The urban scenario made up of markets, infrastructures, regulations, trajectory and social fabric will determine the conditions for innovation and the possible achievement of the city's challenges. Due to this reason cities require a political leadership that is capable of establishing complicities with the private sector that, on the one hand, promote both development and economic growth based on creativity and knowledge and, on the other hand, help to facilitate social improvement. ■

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9 The knowledge or epistemic communities are those that share codes, languages, discourses and perspectives. (Earl, 2001).
10 http://ecole-ete.hec.ca/en/

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INCORPORATION
OF MEDIUM-SIZED CITIES TO THE CATALAN INNOVATION SYSTEM. THE INNO4AGRO CASE, LLEIDA'S SPECIALIZATION STRATEGY

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Geography and innovation systems
National and regional innovation systems
● *What is currently understood as innovation?*

Innovation -understood as the generation of new products and services that often shift existing ones-, has increasingly been imposed as the main contributor of economic and territorial development, from Schumpeter (1942) and Solow (1956). However, three relevant nuances have appeared in this field, which have given a much broader explanation of what innovation means.

First, in the last two decades the idea that innovation is an exclusive phenomenon of the private sector has been abandoned. Most studies already consider it a social process, with the participation of a wide variety of agents. Innovation and entrepreneurship are typical of private organizations, but they are developed jointly with civil society, the academic world and public administrations. Advanced models, such as the triple helix (Etzkowitz and Leydesdorff, 2000) and the quadruple helix

(Carayannis and Campbell, 2009) are representative of this line. The objective of the innovation is not only to do business, but to solve public social and environmental problems (Mazzucato, 2014).

Complementarily, innovation has gone from being a process, rather linear (R & D & I), to being a system. This evolution has caused innovation to be necessarily more complex to study and carry out (Isenberg, 2011; Edquist and Johnson, 1997). But, at the same time, innovation systems provide a more adequate conceptual framework to analyze the various participating organizations, the relationships between them and the context in which it occurs. In this sense, open innovation (Chesbrough, 2006) represents an effective concept to describe the nature of this system, since it focuses on relationships outside, and not within, organizations.

• *Does geography matter in the development of innovation?*
Finally, in the third place, geographical study has been incorporated into innovation. From the western industrial decline, an attempt was made in the 1970s and 1980s to answer why some regions worked better than others. The industrial districts (Marshal, 1920), its advanced Italian version (Beccatini, 1998) and the milieux of innovation (Maillat, 1988) introduced the idea that the geographical aggregation of the agents provoked a bet-

ter reaction in the changing markets and, therefore, generated more innovation and growth. Looking for what drives innovation in these regions, the theory of endogenous growth (Romero, 1990, Lucas, 2001) states that the key factor is the identification of development strategies based on internal strengths. Although it was later proved that innovation systems are necessarily open and global, many case studies show that it is just as important to look inside. In the 1990s, the regional innovation systems (Lundvall, 1992) and the clusters (Porter, 1990) confirmed that, when it comes to fostering innovation, geography matters, in its different scales and with its different backgrounds.

The differential role of cities in innovation systems

● *What role do cities play in innovation?*

Robert Florida (1995) introduced new ideas about the relationship between cities and innovation. He stated that it is in the cities where innovation happens, thanks to the diversity and concentration of individuals of the so-called creative class. Even so, there are serious debates about the role of the local scale, often considered as competition by regional and national scales. These debates warn of the limitation of vision and resources at local scale and assume that innovation cannot be located because it is developed through global value chains.

Conditioned by this conceptual discussion, these theories of the value of the local scale have not been a real influence on the research and innovation policies of national and regional governments. In other words, these governments do not consider, in general, that the local scale is within their innovation system.

Even with this exclusion, local governments do perceive themselves as actors that, in so far as they can create or improve local conditions of growth, can influence the promotion of competitiveness. This has resulted in the generation of a whole set of policies for local development and economic promotion that, in a progressive manner, have incorporated concepts linked to innovation systems such as clusters, support for business growth or training for innovation.

● *The European strategy of intelligent specialization (RIS3), which new things does it bring?*

The approval, in 2012, of the RIS3, the European strategy of intelligent specialization (within the framework of the new Europe 2020 strategy for the period 2014-2020) has placed innovation at the centre of the economic growth model of the European Union , asking the regions (McCann and Ortega-Argilés, 2015) to articulate more integral responses to the needs of the innovation system, but also to recognize specificities in the innovative potential of each region, according to the different stages of development of each one.

Among the different funds available to the EU, the ERDF has been an indispensable tool for the promotion of regional competitiveness and innovation since the first periods of funding, although it has been in this last period when innovation has been central (Capelo-Tatjer, 2016). In this sense, out of the eleven thematic objectives defined by the European Commission, the RIS3 specifically addresses the first of these objectives, the TO1 "strengthening of research, technological development and innovation", establishing, as an external condition in order to receive ERDF funding, that the regions prepare their own RIS3 regional strategy. The generation of regional competitiveness is sought through the discovery, as a system, of new areas of innovative activity based on differential aspects of the territory.

The European Commission developed a specific methodology, entrepreneurial discovery, for the regions to be able to design these strategies in a participatory manner and determine their areas of expertise. So far, more than 160 European regions have presented their specialization strategies, specifying mechanisms and programs for which they request European co-financing (McCann and Ortega-Argilés, 2016).

● *Does the local scale make sense in the strategies of smart specialization (RIS3)?*

This recent strategy, the RIS3, could, according to the authors, contribute with some empirical evidence to overcome the previous debate, on the relevance of local scale in innovation systems and strategies.

The RIS3 constitutes an important innovation in the current programming cycle of the European structural funds, not only because it is a condition for accessing the ERDF, but also because of the conceptual change and the operational challenges generated by its introduction (Foray, 2015; Morgan, 2016). At the same time, nevertheless, doubts have been raised about the viability of these strategies and it is pointed out, first of all, that one of its more critical aspects is the ability to translate the declarations of intentions contained in the

> *Not always more diversity translates into better innovation, nor does the big city necessarily produce more varied interactions*

RIS3 into concrete projects (Capello and Kroll , 2016; McCann and Ortega-Argilés, 2016). Second, there is evidence that most EU countries and regions are more willing to diversify than to specialize in certain sector areas.

In light of these first evaluations of the RIS3, which explain that regions and countries have difficulties in the effective specialization and implementation of their strategies, this article highlights the need for a greater involvement at local scale in the RIS3 and, in general, in the innovation systems, since it can be part of the solution to the limitations listed. The aim is to illustrate this statement based on a territorial specialization project (INNO4AGRO), with an active role for the local environment. The project is based on the collaboration between the agents of the innovation system of the territory of Lleida and its specialization in the field of new technologies applied to the different phases of agri-food production.

**Urban and rural dynamics
in innovation ecosystems**

● *Can innovation be done in rural areas?*

However, everything that has been written on innovation systems at local scale has almost always been related to the big cities, given the density, diversity and intensity of the interactions between the agents that live there and, on the other hand, their connection with global value chains. Therefore, another question is raised: could we conclude that it is not possible to innovate in rural or peripheral areas?

Shearmur and Doloreux (2016), among others, respond in a solid way that it is not only possible but that these quieter and less populated spaces are a perfect complement to the big global cities, for the innovative agents and their activities. This reality has been almost invisible given the urban diversion produced in the studies on creativity and innovation and the greater facility to focus on phenomena of concentration than dispersion.

● *How is innovation produced in rural areas?*

First, we observe the innovation process. The first phase of generation of innovation is not the same as the second phase of marketing and adoption of innovation. The first, which does not need information as urgently, can happen everywhere, also far from the cities, while the second, which includes market strategy, financing research and innovation scaling, seems to happen exclusively in the cities.

On the other hand, the relative need for information and interaction differs according to the type of activity and type of innovation. A service company for rural tourism establishments or a technology one for the agri-food sector will surely prefer to be located close to the rural environment instead of the big city.

Finally, not always more diversity translates into better innovation, nor does the big city necessarily produce more varied interactions between agents (McPherson, 2001). In the city, personal networks are relatively homogeneous, although there is more diversity as a whole. Rural networks, on the other hand, are more varied socially, politically and professionally, because of the fact that they have a smaller number of people (Beggs, Haines and Hurlbert, 1996).

Shearmur argues that there are no purely urban or rural innovative agents, but that there are people who spend more or less time in each type of environment. The processes of creativity and innovation require contexts of high interaction, agglomeration and intensity, but also of periods of calmness and introspection. There are more divergent moments in the process (especially those of preparation and production of innovation) and others more convergent (especially those of incubation and inspiration), and there are also more extroverted and other more introverted innovators. In a way, these combinations of activities and types of people make it more appropriate to have an urban or a rural environment, at different moments of the innovation process. Therefore, the places, cities or rural populations, would rather be intersections of innovative trajectories (Massey, 2005).

**The PECT: an innovation instrument
of the RIS3CAT at local scales**

The Catalan strategy of intelligent specialization (RIS-3CAT)

● *What is the RIS3CAT?*

The Generalitat of Catalonia approved in 2014 its RIS3, the

RIS3CAT[1], within the framework of the EACAT 2020 strategy. It defined seven areas of specialization, which in fact cover the main economic sectors of the region: food, energy and resources, industrial systems, industries based on design, industries related to sustainable mobility, health industries and cultural and based on experience industries.

A series of instruments for assessing and transferring knowledge, generating highly innovative and collaborative actions (RIS3 communities), financing of R + D with high technological risk (technological hubs) and promoting participation of R + D + I agents in major European initiatives in emerging technologies such as graphene (emerging activities) were defined in the RIS3CAT in order to articulate the projects of the innovation system. See figure 1

● *What are the PECT?*

The specialization and territorial competitiveness projects (PECT for its Catalan acronym) were designed as a counterpoint to these more sector instruments. They are instruments which channel financing to local administrations through a competitive mechanism. Their objective is to promote multi-agent innovation projects that contribute to the economic transformation of their territories. Therefore, they aim at putting into practice concepts of the urban economy (such as competitive advantages) or innovative milieux at the local level.

In 2016, the first call for PECTs was approved, open to all local entities (from municipalities to councils) of more than 20,000 inhabitants, for a grant of 50 million euros.[2] The projects had to be framed in one of the areas of specialization of the RIS3CAT and have a high innovative component based on its assets and capabilities. All the agents of the quadruple helix could participate, from research centres, universities, companies, business associations and local administrations, even though in order for them to be beneficiaries they had to be non-profit entities.

This is a relatively unique instrument in Europe, as the analysis made for European projects such as INFOCUS or RELOS3,[3] have acknowledged, which has made it possible to highlight the potential of the intelligent specialization at local level (Garcia Brustenga and Lazzeri, 2018). At European level, several cities have developed RIS strategies, either on their own or as a complement to regional strategies, but they are central metropolitan environments within their countries and regions. The PECT, on the other hand, plays a leading role in local environments from 20,000 inhabitants onwards, often distanced from the metropolitan dynamics of large cities.

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2 Base of the tender: http://portaldogc.gencat.cat/utilsEADOP/ PDF/7113/1491582.pdf.
3 These project web pages can be consulted for more details: RELOS3: From Regional to Local. Successful deployment of Smart Specialization Strategies, https://www.interregeurope.eu/ relos3/; InFocuss: smart Specialization at city level, http://urbact. eu/urban-dimension-smart-specialisation-building- two-way-bridge.

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1 http://catalunya2020.gencat.cat/ca/estrategies/ris3cat/.

Figure 1. Instruments defined by RIS3CAT

Instruments

● Communities of the RIS3CAT
● Emerging activities
● Development of key technological capabilities
● Research infrastructures and technology transfer
● R & D collaborative projects
● Assessment and transfer of technology
● International cooperation
● Innovative public procurement
● Specialization projects and territorial competitiveness (PECT for its Catalan acronym)

Public policies

● Digital agenda
● Entrepreneurship
● Eco-innovation (innovation at the service of the green economy)
● Non-technological innovation
● Training and talent

Source: RIS3CAT Document. Executive summary January 2014.
Author's note: A new RIS3CAT document was published in May 2018. 2015-2020 Action Plan that has increased the number of instruments.

It can be argued that it is an instrument that has special meaning in an administrative structure such as the Catalan one. In this sense, the Catalan administrative structure grants municipalities and other local entities competences and financing that make them relatively autonomous with respect to the regional government, something that does not happen in most of the Spanish regions and European countries. Other elements that contextualize the unprecedented appearance of this instrument in Catalonia are the presence of medium-sized cities with economic strength throughout its territory, an important municipality tradition and the significant development of local economic promotion policies implemented by most of local Catalan entities in the last 40 years (Gomà and Subirats, 2001).

Projects and expectations of the first call for the PECT (2016)

● *What reception has the first call for the PECT had in Catalonia?*

The approval of the PECT specifications caused strong expectations throughout the territory. Several platforms of the local Administration, such as councils or associations of municipalities, were interested by the publication. Also information sessions were held by the Generalitat throughout the territory to make it known. The expectation was high, more so as it was accessed in a clearly competitive way. Developing a PECT implied the need to do an important previous job of reflection around the areas of specialization, while collaborating with different agents of the territory and with a strong emphasis on innovation, something that not all local entities were familiar with. In addition, they had to have the financial and economic capacity to address them (50% co-financing without advance payment) and some kind of previous strategy that framed the project and the activities that had to be done, something that not all territories had after years of economic crisis and austerity.

● *What results has the first call of the PECTs had?*

Finally, in the September 2016 call, 36 projects were submitted by local entities from the four Catalan provinces, of which 25 (70%) were definitively approved in February 2018, with co-financing from the FEDER fund (30.5 million Euros). The approval took place almost two years after the opening of the call, a relevant delay considering that the execution period is in 2020 and in order to obtain the extension the projects must have already executed 70% of the expenditure. By province,

Table 1. Areas of specialization selected for the projects presented in the 1st call of the PECT (some had more than one scope)

Area of specialization	No. of projects
Food	10
Energy and resources	7
Design industries	2
Cultural industries and based on experience	10
Health industries	5
Sustainable mobility	3
Industrial systems	5

Source: author's elaboration with information from the final award of contract.

Barcelona concentrates the highest number of projects presented, but Tarragona achieves 100% approval of the projects presented by entities in this territory, followed by Girona, with 78% of the approved projects. According to the typology of entity, 39% of the projects were presented by the four provincial councils in Catalonia and the rest, by county councils and municipalities in equal parts.

● *Are PECTs an emerging model of innovation?*

This study tries to demonstrate that it is possible to include agents and local scale approaches in the regional RIS3, notably, through the case of the PECT within the RIS3CAT, and one of the first projects approved in its first call, the INNO4AGRO, from the city of Lleida. This follows a new emerging model, at least in Catalonia, which incorporates the local policy of innovation and specialization in all the regional strategies and is currently being designed and implemented in some of its cities, counties and provinces.

Table 2. Projects submitted by province

Province	Presented	Approved	% approved
Barcelona	15	10	67
Girona	9	7	78
Tarragona	4	4	100
Lleida	7	4	57

Source: author's elaboration with information from the final award of contract.

The case of the PECT in the city of Lleida

Background of innovation policy in the city of Lleida

● *Was Lleida already specialized?*

In the 50s and 60s, Lleida's counties found their own way of economic development based on the hydrographic network, the notorious network of irrigation and the communication axis, with the main road A-2 as the main driving force. The Horta de Lleida (Lleida's agricultural region) became the benchmark of intensive agriculture in the inner Catalonia (Ignasi Aldomà, 2009). Lluch and Seró (1970) were the references when studying the importance of what they called the fruit region of Lleida and, meanwhile, Solé (1990) highlighted the central role played by the city in the expansion of the cold industry (food preservation) in the region from the 1950s, an essential industry for the production and marketing of pear and apple.

The intensive fruit culture allowed to innovate and continues doing so nowadays. The levels of productivity increased considerably thanks to the progressive mechanization of the field, the use of fertilizers, phytosanitary products, irrigation equipment, refrigerated chambers, advanced logistics, experimental fields, etc., and today, the productivity has increased thanks to the new varieties adapted to current tastes, integrated production, ecological agriculture, new post-harvest techniques, precision agriculture, geolocation, big data and robotization. As Morell, Maurel and Aldomà (1980) state: "The development of the intensive production of sweet fruit has been the great innovator of Segrià's agriculture".

The intensive production of pigs and chickens was developed alongside it, having animal feeds companies and co-operatives as promoters. The organizational innovation that allowed the intensive livestock model to spread in Catalonia were the integration contracts.

Finally, in this context, the tertiary sector of the city of Lleida was constituted by the services entailed in a provincial capital (administrative, health, educational, railway and regional commercial centre services), but also, to a large extent, by the activities promoted by specialized sectors and by the creation of new institutions that became references, such as the Fira de Lleida to promote fairs ans exhibitions (1959) and Mercolleida auction market (May of 1971), from where the creation of the Indulleida company of processed fruit was promoted in 1979.

● *What was the most valuable milestone for the Lleida innovation ecosystem?*

The instruction of farmers and agricultural technicians was considered a priority, since farmers had to be trained in new techniques, this role was assumed by the provincial council of Lleida in the first years. Afterwards, the inter-institutional and social consensus and the political will, since 1968, managed to recover university studies in Lleida. First as extensions of the universities of Barcelona, later as Estudi General de Lleida and, finally, in 1991, creating the University of Lleida. Ramon M. Puig, in Echauz (1995), stated: "The great socio-cultural and economic fact of the twentieth century in Lleida has been the reimplantation of the University. The University will generate structural changes in the professional, economic and cultural levels of the city."

Thus, since the 1960s, the years of "fruit boom", the region of Lleida is a cohesive area due to the polarization effect of the city of Lleida as the center of services, the hegemony of the agro-industrial economic model, the existence of a coherent urban network with the presence of dynamic companies distributed in the main urban areas, with the proximity to the main road A-2 and with the innovative knowledge provided by the incipient university studies.

● *What role has the local Administration had in Lleida since then?*

In the 80s and 90s the consolidation of the active role of the local administrations of Lleida was verified, especially in:

• The increase of administrative services and services to companies and production, such as logistics and transport (Pujadas, Aldomà and Enciso, 1995) and also the promotion of ICT at all levels stands out.

• Occupation and promotion policies, creating new agencies responsible for undertaking occupation policies, [4] economic promotion, [5] business incubators and tourism promotion.[6]

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4 Institut Municipal d'Ocupació Salvador Seguí, autonomous body of the City Council of Lleida (1996).

5 Consorci de Promoció Econòmica de l'Ajuntament de Lleida (1993) and Patronat de Promoció Econòmica of the Provincial Government of Lleida (1994).

6 Intercomarcal Tourist Board of the Provincial Government of Lleida and the Ara Lleida brand (1989) and the Municipal Tourist Board of the City Council of Lleida (1994) and the Lleida Convention Bureau.

• The creation of the University of Lleida (1991) and the gradual increase of degrees and diplomas and post-graduate degrees.

• Active participation in networks of municipalities and occupying positions of relevance in areas such as the promotion of the information society in the Spanish Federation of Municipalities and Provinces (FEMP for its Catalan acronym) and the systematic preparation of agreed strategic plans since 1996.

• The creation of specialized monographic fairs and international shows such as Municipàlia (1981) and Eurofruit (1986). "The fairs have to be not only the place of exhibition, but also a meeting place, of reflection and debate of each sector", Antoni Siurana, in Echauz (1995).

• The recovery of the river "El Segre" as a vertebrating element and of natural spaces, with special attention to the environmental aspects and the Horta de Lleida (Lleida's agricultural region).

● *When does Lleida begin to prioritize innovation?*
The main commitment of the city to promote innovation, already within the 21st century, has been the creation of the Scientific and Technological Agri-Food Park of Lleida in 2005, promoted jointly by the City Council of Lleida and the University of Lleida. Technological reference centres -such as Eurecat Lleida, IRTA-Fruitcentre and the Technological Forest Science Center of Catalonia- have been linked there.

The Provincial Council of Lleida (Diputació de Lleida) set up in 1990 the Ground Analysis Laboratory in Sidamon (Pla d'Urgell) alongside the UPC and the Agrupació de Cooperativas de Terres de Lleida, the Technological Forest Science Center of Catalonia (1996), the "Centre de Testatge de la Raça Bruna dels Pirineus" to protect a native breed of cattle (2003) and the European Centre of Innovative

Companies of Lleida, CEEI Lleida (2005). Later, the Provincial Council of Lleida financed the creation of the Center for Advanced Biomedical Research, CREBA (2015).

In that period, the Strategic Plan of the Universitat de Lleida (UdL) defined four preferred areas of activity and promoted an institute or research centre in each one of them. It also gave a strong impulse to the University-Company chairs and the Unesco-UdL Chair of medium-size cities. Together with other universities, on 2011 it created the Campus Iberus Consortium to manage the performance of the Campus of international Excellence of the Ebro Valley approved by the Spanish Ministry of Education (2010).

The Provincial Council of Lleida, the City Council of Lleida, the Chambers of Commerce and Industry of Lleida and Tàrrega and the University of Lleida promoted in 2011 the GlobaLleida Consortium, an inter-institutional project to integrate all the economic promotion and projection activity of the territory into a single entity. Global Lleida Consortium has promoted a venture capital fund and works on the basis of identified clusters.

In the words of Àngel Ros (2011), "Lleida is an innovative city. Nowadays, cities have to be involved in the innovation process of the different areas of society: from an economic point of view to a caring for people. [...] A city has to be innovative to get a relevant role within the network of cities of which it is a part of. Today the future of every city depends on being a national or international benchmark in some field. Becoming an international reference means to be known for its excellence in some productive specialization. Therefore, a city has to pursue its specialization and has to do it necessarily through innovation. Size is less important than innovation. Consequently, promoting innovation is much more important in medium size cities such as Lleida than in large cities."

As a result of all this work, in 2011, the city of Lleida was awarded the City of Science and Innovation award granted by the Spanish Ministry of Science and Innovation. This award rewards the commitment of the cities with R + D + I and their contribution, at a local level, to the change of the productive model.

The entrepreneur discovery process (2014-2016)
In 2014, when the intelligent specialization strategy of Catalonia was launched, the city of Lleida began a process of reflection

Table 3. Application of the specialization criteria according to RIS3 in the case of Lleida

Critical mass	The territory of Lleida concentrates 40% of the employment of the Catalan primary sector and 17% of the sector agri-food (including industry). The city of Lleida is presented as a service supply center for knowledge and talent for the whole of the territory and its productive fabric.
Global competitiveness	In Lleida the activity of the food industries represents up to 30% of its GDP and 65% of exports. Lleida ranks second in increase in exports nationwide (2008 data), with the majority of exports from the province of Lleida, 68%, corresponding to agri-food products.
Degree of specialization	The selection of the agri-food industry, which includes all its chain of value, focuses on the improvement of innovation and the absorption of technology of companies is well defined.
Previous collaboration	All the partners and entities participating in the project have previously collaborated in an active way, developing joint initiatives which are aligned with the specialization in agri-food of the territory. The creation of the Parc Científic, the holding of several conferences and congresses and the various meetings carried out under the PECT for the entrepreneur discovery process are an example of this.

Source: INNO4AGRO Project report.

through the city council and a series of the key agents of the economic and innovation system of the territory on how to use this opportunity for economic transformation in the territory. Representatives of the triple helix of the territory stood out as agents of the central nucleus of the process: the Public Administration (the City council of Lleida, GlobaLleida), the knowledge field (the Universidad de Lleida, the Parc Científic i Tecnològic Agroalimentari) and the private sector (driving and innovative companies from the sector in the territory). The City Council of Lleida, as a public administration, exercised the leadership of the process from the beginning, although the participation of all agents in the system was essential.

Using the methodology of entrepreneurial discovery, they discussed what activities could generate more opportunities for innovative specialization. Two of them stood out as the most appropriate, based on the RIS3 criteria: on the one hand, those linked to the digitization of the tourist experience and the new markets for natural, gastronomic and sports tourism; and, on the other hand, those related to innovation (digital, sustainable, biotechnological) of the different phases of agri-food production. The latter, however, was the one the majority were in favour of regarding the opportunities to be a transforming tool of the territory and to generate highly specialized innovative activities, given the high significance of this sector to the entire province and its relevance at a Catalan scale.

It was also considered that this was the area where there was more growth margin, given the evolution of information and communication technologies and the identified challenges linked to low technification, little innovative capacity and difficulty in attracting skilled workers. It was an area that allowed synergies to be generated and had a positive impact on the activity that had not been chosen in the end –i.e. tourism linked to the value chain of agro-industry- all across Lleida.

The project received the name INNO4AGRO: an innovative ecosystem for an intelligent agri-food sector, and raised three strategic objectives:

• Improve the productive capacity and competitiveness of SMEs.

• Strengthen Lleida as a center for innovation.

• To ensure that specialization was the driving force behind the transformation of Lleida's entire economy.

The INNO4AGRO project was submitted to the first call of the PECTs led by the City Council of Lleida and, as beneficiary partners, the Universidad de Lleida , the Parc Científic i Tecnològic, Turisme de Lleida and the Institut Municipal d'Ocupació.

In addition to these partners (with the capacity to execute projects and, therefore, to receive financing), the project had a series of non-beneficiary partner entities, with the aim of ensuring the complicity of the economic and social fabric of the territory: six companies in the agri-food sector (from fruit to pork, through wine) and three relevant platforms in the sector: the associations Lleida Drone and Ruta del Vi de LLeida and GlobaLleida.
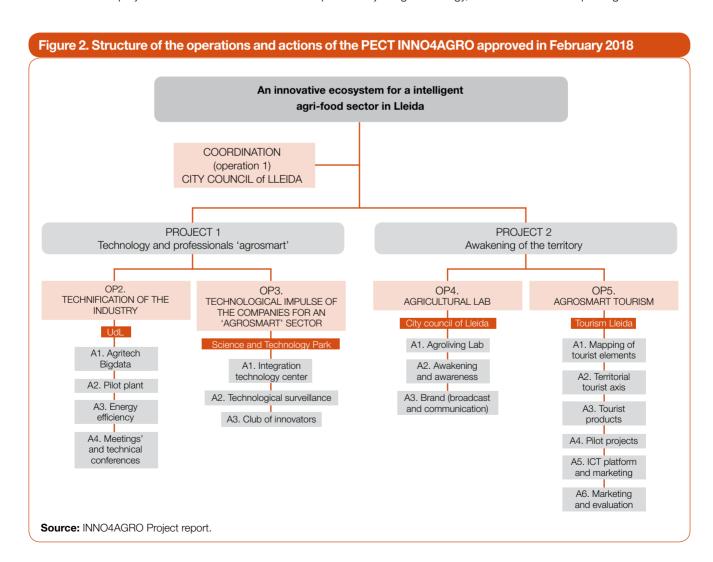
The project presented six operations, each executed by one of the partners, except for the City Council, which had two operations (one of them, the coordination of the project), and a final budget of 4.5 million Euros.

The approved Project
The evaluating body of the Generalitat of Catalonia approved the INNO4AGRO project with minor modifications with respect to the original. The PECT consortium accepted them and the project was finally approved with a budget of 4.2 M € (co-financed by the European Union FEDER by 50%), five transactions and four partners. Figure 2 shows the basic structure of the approved project.

It is noted that the project has activities that are based on innovative concepts of innovation policy theories, such as the creation of a space that allows generating an innovative ecosystem (OP4) and the generation of mechanisms of interrelation between both internal and external agents as the club of innovators (OP3). There are also operations more specifically aimed at improving the competitiveness and innovative capacity of the agri-food sector from a scientific standpoint (OP2) as well as a business one (OP3). It stands out how the project aims to also generate synergies with the field of tourism (OP5), joining technology, activities based on improving the visitor ex-

Figure 2. Structure of the operations and actions of the PECT INNO4AGRO approved in February 2018

Source: INNO4AGRO Project report.

perience and the exploitation of tourism assets in the territory as levers of the agri-food sector.

The project foresees the implementation of actions such as the Agritech Big Data, the Agroliving Lab, the food technology pilot plant or the technology-based marketing platform aimed at the agrotourism sector, which will become structures that promote innovation with durability beyond the PECT.

Learning

Based on the analysis of the first PECTs and, specifically, in the case of the city of Lleida and the INNO4AGRO project, the following learning points have been established:

➤ **The inclusion of the local scale seems to add value to the Catalan innovation system.**·

Promoting the innovative transformation of traditional sectors also from medium-sized cities such as Lleida allows: :

● Achieving **agreement and balance in the governance** between the different agents of the triple helix located in and with influence on the territory. The governance of local intelligent specialization projects does not follow any common structure that can be proposed or imposed from a regional level. Each local territory has its own history, balance and needs of power, which generate different types of organizations and influence among them.

● Addressing a **shared and holistic vision of the system**. The PECT has, for two years, created the generalized need for collaborative culture and holistic vision, both within and between the organizations involved. Intelligent specialization has brought a different way of designing policies by transforming a scenario of individual ideas and separate management of the innovative ecosystem functions into another scenario where everyone is aware of being part of the same common strategic Project. A scenario that is more integrated, more focused and more ambitious in terms of territorial impact.

● Consensualizing a **true specialization** more naturally, within the framework of a diversified region. The concept of specialization has been widely received and applied by local agents. It seems that it is not difficult for the local government, or for the other partners, to share the discussion and agree on the area of specialization that, on the other hand, in cases like Lleida, has its antecedents. It may be, therefore, easier to specialize at a local level. The region, Catalonia in this case, did not have to – or in fact want to - specialize in one or a few

areas, thanks to its clear diversification characteristic of a complete economy.

● Evolving the role of public administration, since **innovation became central in the new policy of local economic development**, orienting it towards the needs of creation and development of markets and creating a new leadership role for local governments. The city council is drawing its new role of co-leadership, together with the regional government and other local territorial administrations, in innovation systems, defining itself as a coordinating, leveraging and facilitating instrument of innovation.

● **Organizing the distribution of work between local and regional governments**. The former, concentrating on the governance and execution of the project; the latter, establishing criteria, ensuring quality, monitoring, promoting training and joint learning and coordinating the PECT, relating them to other points in Catalonia that can generate synergies both in the sector (food, for example) and transversal facilitating technologies with application in several sectors. In the opinion of the authors, incorporating the local scale does not mean an exempting delegation by the regional government.

➤ **The inclusion of the local scale by the RIS3CAT may be opening a more efficient scenario in regional innovation policies.**

Until now, regional innovation policies had not seriously and systematically considered the local scale in its design or execution. The complementary action of the regional and local scale, conveyed through a formal instrument such as the PECT, can be a new good practice for the regions of the European Union in the RIS3 of the next funding period (2021-2027).

➤ **Rural areas are as important as urban areas in the consolidation of a regional innovation system such as the Catalan one.**

Medium-sized cities in rural areas such as Lleida also have a relevant role in the innovative ecosystem, both for the province and for the region. Especially in sectors such as agri-food, natural resources and tourism, these areas are part of the value cycle of the metropolis, just as, conversely, metropolises are an important part of the competitiveness of the activity that takes place in the rural area. Therefore, we would have to consider cities such as Lleida and metropolises such as Bar-

celona as a single ecosystem in which both locations cover different needs of the innovation process of entrepreneurs and companies in the country.

In short, this article highlights the innovation that the PECTs represent, within the framework of the Catalan RIS3, as an unprecedented case of public-private policy in which the region promotes innovation and shares leadership with the local scale. The consequent multilevel and systematic governance can be optimal for the joint impulse of innovation, apart from contributing to territorial rebalancing and to exploiting the synergy between the competitive advantages of metropolitan agglomerations and those of slower rural environments. ■

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FROM CLIENT
TO CITIZEN: UNIVERSAL BASIC INCOME AS AN INNOVATION POLICY PROPOSAL IN URBAN ENVIRONMENTS

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Advanced economies have historically deployed substantial efforts and resources to foster innovation. Innovation is an undoubted force for economic growth and prosperity. Nevertheless, there are growing signs that, although innovation (and, above all, technological development) has given rise in recent years to remarkable results in the generation of wealth, the phenomenon in relation to the distribution of this wealth has not been considered. At present, there is a growing social debate about the possibility of a jobless future (a future of labour shortages and widespread inequality, thanks to the replacement of people with machines). In the middle of this debate emerges the possibility of introducing a universal basic income (UBI for the acronym in English) as a corrective mechanism. The proposal is to offer money for nothing: give every citizen an unconditional cash amount (regardless of the working conditions and level of wealth of the individual), basic (to avoid falling below the threshold of poverty) and universal (for the entire world). This measure is presented as a corrective initiative, af-

ter the positive effects of the innovative phenomenon. In our opinion, however, instead of treating it as a corrective measure, we argue that the UBI can become an element of an innovation generating policy, with the capacity to correct inequality and generate new economic value at the same time. With this article, we intend to explore the link between innovation policies and social welfare policies, with the UBI as a common link. We argue that the UBI can become the missing link between innovation policies and those of social welfare, and become a powerful instrument to stimulate innovation if its deployment focuses on local and urban environments. We justify this idea as the point of destination of the logical evolution of innovation policies over the last decades.

Introduction: innovation, economic growth and inequality

Since Schumpeter introduced the term innovation in the modern economy as the phenomenon of introduction of new technologies in the market, this concept has become a mantra for managers and entrepreneurs, and an inevitable need for every economy to achieve growth. Innovation is understood as the "theoretical conception, technical invention and commercial exploitation of new ideas" (Trott, 2008). There is enough economic evidence that correlates the degree of innovation of a country, its economic growth and its personal inco-

me (see, for example, Freeman, 2002), and that establishes causal relationships between these variables.

Under this conceptual framework, governments have been striving for decades to deploy innovation policies. Policies that seek to create institutional environments that encourage the innovation of companies in specific locations have been very successful in the economic development of many countries, regions and local communities, from Israel to South Korea, Taiwan, Singapore, Finland, Germany or the United Kingdom; Silicon Valley has become the paradigm of innovative cluster imitated throughout the entire world. However, social aspects have been separated from the basic conceptions of innovation policies, which in general deal with the problem of wealth creation (letting welfare policies solve wealth distribution failures). The underlying framework of this logic has possibly been the conviction that the first objective of the company is to obtain benefits and, based on economic activity aimed at maximizing business results, positive externalities are generated that flow spontaneously towards society, generating shared wealth.

According to Nobel Prize Milton Friedman (1970), "the sole purpose of a business is to generate profits for its shareholders". For this current of thought, the only social function of the company is limited to the benefits of the shareholder (in fact, the positive impact on society is a derivative of the positive impact on the shareholders' income statement). In his writings, Friedman explicitly mentioned the term social responsibility, believing that by maximizing individual benefits, by stimulating intense competition among companies, the economic system could offer better products and services and satisfy the consumer with a growing degree of excellence. If a company developed activities with explicitly negative social impact, the consumers would stop buying their products. Thus, there is an automatic mechanism of self-regulation driven by the effect of the invisible hand of Adam Smith that would achieve an optimal balance of shared prosperity. With the enlargement of market economy systems, the wealth of nations has grown uninterrupted over the past two centuries. The economy has been driven by the effects of the industrial revolution and market forces, which have lifted millions of people out of poverty and have brought undeniable added benefits to humanity, in all aspects, including education, communication, health, mobility and energy. Public innovation policies reinforce the market economy system, addressing some of the problems of the system (mainly, market failures, where there is a suboptimal behaviour of this, such as

research and development), generating public incentives to accelerate technological change, to improve the competitiveness and growth of companies and nations.

However, 2008's great recession, and the post-crisis scenario, have seriously challenged the old paradigm. Despite accelerating technological change, inequality extends into advanced economies. Absolute poverty in the United States (the country with the highest gross investment in R + D in the world) has continued to grow since 1980, and the wealth ratio of 0.1% of the population has increased five times in three decades (Freedman, 2016). Since 1972, the net productivity of the economy has increased by 140.9%, while wages have only increased by 7.8% (Economic Policy Institute, 2013). In recent decades, despite the advances in automation, robotics and big data, among other disruptive technologies, we have witnessed a large decoupling between labour productivity and average income or job growth (Brynjolfsson and McAfee, 2014). The value created by technological change seems to have only been captured by a small segment of the population. Large digital platforms such as Amazon, Facebook, Apple or Google are the paradigm of this dynamic. These companies have unparalleled technological competitive advantages, they have global brands, economies of unbeatable scale and reach, segmented reach to the user and great positive network effects. They are immense machines of generating profits and attracting investment capital, in a feedback effect that expands them, advancing towards growing niches of the old traditional economy. Nevertheless, as digitization and automation spread, employment generation weakens: these technology platforms are less intensive in creating employment than the old analogic leaders. Designed to maximize economic efficiency and reduce costs, digital companies are less able to distribute wealth through employment and wages than traditional manufacturing companies.

In summary, political responsibles face a paradox: on the one hand, developed nations move towards a paradigm of abundance thanks to exponential technological development (Diamandis, 2012). On the other hand, yet, they are witnessing a growing competition for jobs and the threat of a future of scarcity of employment due to the replacement of people by machines (Silva and Lima, 2017). Under the current model, capitalism seems to evolve towards a game of the winner takes it all, in which the richest segments accumulate progressively more wealth, and from which the middle classes, the big losers of the new scenario, are expelled. An illustration of this paradox

is the case of the United States, a country widely recognized as one of the global innovation economies, where levels of inequality exceed those of any other society, anywhere in the world, at any time of the history of humanity (Picketty, 2014). In this context, traditional innovation policies (whose ultimate goal is to accelerate technological change) are no longer a driver of national prosperity. And, while many academics and thinkers still see the creation of economic growth as the ultimate goal of innovation policy, more and more voices are rising (such as the OECD and the United Nations Conference on Trade and Development) that perceive the maximizing of domestic welfare as the end point of innovation policy and technological change (Mytelka and Smith, 2002). This raises the question of how we can redesign these policies, designing new instruments of social innovation, to turn them into an engine of shared prosperity.
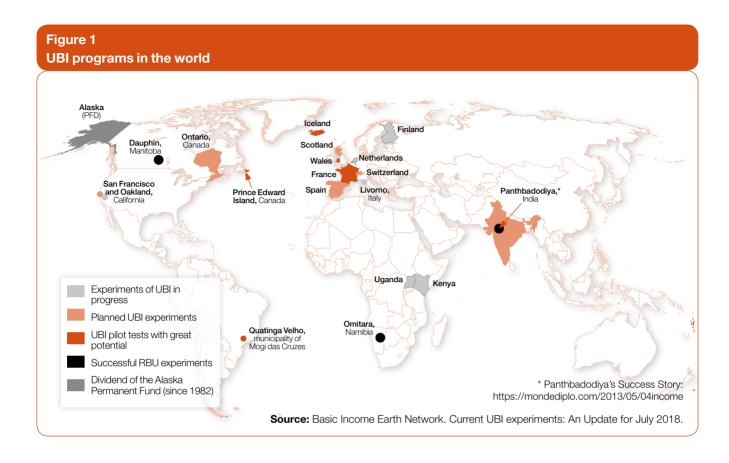
The emergence of the universal basic income concept

Since the crisis of 2008, the idea that innovation should not only be considered an economic concept emerges strongly. Possibly, a more integral innovation policy point of view would have to incorporate the social dimension, taking into account that the balance and the prosperity of the system require both production (offering policies: stimulation of competitiveness and technological change) and the distribution of wealth (stimulation of consumption and elimination of poverty). There is, in fact, a growing consensus on the need to find new forms of innovation that provide economic value and positive social impact to fight against some of the main threats of the capitalist system, such as inequality, weak consumption and populism (Van der Have and Rubalcaba, 2016, Mulgan et al., 2007, Pol and Ville, 2009).

Recently, the concept of universal basic income (UBI) is being proposed as a possible solution to the distribution problems posed by post-crisis capitalism. A UBI implies the provision of a fixed amount of monthly income to each citizen, regardless of the conditions they have (whether of their income, of their estate or whether or not they are employed) (Widerquist et al., 2013). The UBI eliminates three main eligibility criteria common in other schemes of social redistribution: the requirement of a demonstrated willingness to work, the recognition of the family situation and the existence of situations of poverty. The only condition of eligibility is residence in the country where the funds are granted (Vanderborght and Van Parijs, 2005). In

most proposed UBI schemes, the monthly payment is designed to ensure that all citizens live at least above the poverty line. In some schemes, the UBI replaces pre-existing social welfare systems, such as unemployment benefits, widowhood, pensions, disability or food vouchers. The defenders of the UBI (existing in all areas of the political spectrum) point out the potential of this system to eliminate the bureaucratic cost of selecting who deserves it or who does not, making it unconditional and universal, and, therefore, much easier to manage. According to its defenders, the UBI would make the social welfare system more agile and consistent, would replace part of the costly (and often inefficient) welfare networks, would avoid the poverty traps (not working to continue receiving the subsidy). It would constitute a direct mechanism of abolition of poverty and stimulate innovation and entrepreneurship by lowering individual risk levels to start new business projects. At the same time, an UBI would solve the potential problems of the systemic collapse due to the failure of the economic demand in the face of a massive technological unemployment scenario favouring the distribution of wealth. For the detractors, the UBI is morally reprehensible (providing money to people who can opt not to develop any economic activity), it is economically unaffordable, it would create uncontrolled inflation and it would increase desirability of the areas where it was offered.

Be that as it may, at present, several pilot tests are under development or have been completed recently, in countries such as Canada, the Netherlands, Finland, India and Namibia (see Figure 1). Knowledge of the direct and indirect economic effects of a UBI is very limited. The attractiveness of the instrument is undoubted, but none of the studies presents the demographic and temporal scale sufficient to obtain significant conclusions. The question that must be answered is, in short, what would be the behaviour of a group of individuals in all the demographic, patrimonial, and income levels, when it is endowed with an unconditional basic income. Critics argue that the unconditional allowance of a monthly income would cause a large number of individuals to stop working, turning them into a kind of social parasite. The defenders of the UBI argue that, in fact, this segment of individuals is already possibly the least productive of the economy, and that the UBI, accompanied by labour market flexibility (preventing social exclusion by defining the same instrument), would mean that the economy was more adaptive and competitive. In the following sections, we support the theoretical and empirical approach to this visi-

Figure 1
UBI programs in the world

Alaska (PFD)

Dauphin, Manitoba

Ontario, Canada

San Francisco and Oakland, California

Prince Edward Island, Canada

Iceland

Scotland

Wales

France

Spain

Finland

Netherlands

Switzerland

Livorno, Italy

Panthbadodiya,* India

Uganda

Kenya

Quatinga Velho, municipality of Mogi das Cruzes

Omitara, Namibia

Experiments of UBI in progress

Planned UBI experiments

UBI pilot tests with great potential

Successful RBU experiments

Dividend of the Alaska Permanent Fund (since 1982)

* Panthbadodiya's Success Story: https://mondediplo.com/2013/05/04income

Source: Basic Income Earth Network. Current UBI experiments: An Update for July 2018.

on, through the creation of a conceptual framework of connection between the UBI and the capacity for innovation. In fact, we argue that the UBI is at the core of new waves of innovation policies, by stimulating the entrepreneurial spirit and economic activity through reducing the level of risk of potential entrepreneurs (Cohen, 2017).

Is the UBI the missing link between innovation and welfare policies?

It seems clear that the UBI is a promising tool to address the problems of poverty, unemployment and inequality, from a mitigating perspective (Vanderborght and Van Parijs, 2005). In this article, we argue that, properly designed and executed, a UBI could also become a driver of economic value creation. Is there an economic and social opportunity cost generated to focus the UBI as a simple correction instrument, instead of perceiving it as a potential driver of innovation? If so, we question that the UBI is only considered a distributive solution belonging to the field of welfare policies, and we note the need to explore the UBI within the frame of all innovation policies aimed at generating economic growth and shared prosperity. And, if the UBI can be incorporated

into the body of innovation policies, then, what is the most efficient approach to do so?

Although the UBI has recently been studied from the perspective of a form of social innovation (Per and Backhaus, 2016), there is no solid link between the innovation research literature and the UBI, nor the contextualization of the UBI in the framework of innovation policies and instruments. Scholars and political responsibles interested in the UBI have considered it primarily as a tool to redesign welfare programs, even as an efficiency tool to reduce costs, minimizing the bureaucracy of state-sponsored social programs. The UBI emerges in a reactive way, as a direct protection against the growing worries about the technological unemployment and the scenarios of the future with lack of work and its precarization (Stern, 2016). Just as most scholars of innovation policy identify their conceptual limits in the creation of wealth, forgetting its redistributive mechanisms as an essential systemic element, the academic community focused on social welfare policies has also largely neglected the analysis of the innovation-inducing effect that could arise from appropriately designed UBI programs. A notable exception are Lucarelli and Fumagalli (2008), who

found that by boosting risk-taking and improving network and learning processes, UBI formulas could induce the promotion of innovation.

There is, in fact, growing empirical evidence of the potential of the UBI as an engine of innovation. The UBI works as a safety net for the most disadvantaged people, but also as a provision of financial resources, which would give them the opportunity to start entrepreneurial activities through the direct provision of minimum cash funds. In one of the first documented experiments of UBI, executed in Namibia during a period of two years between January 2008 and December 2009, there was a significant increase in the number of small businesses in the community generated with the additional income that allowed new brick operators, bakeries and clothing. Competition and productive specialization were stimulated. In addition, small businesses in the community obtained an increase of 300% in total income, distributed among its residents, due to the increase in available cash (Haarman et al., 2009). It seems clear that the UBI increases small-scale investments in impoverished local communities (Standing, 2013). The help in cash results in more business activity and also leads to the creation of employment, a fact that generates an occasional shift of paid employment towards self-employment and entrepreneurship, with less tendency towards migration. A UBI is also an engine for small businesses. Facilitating cash flow stimulates rural economies by increasing demand, with administrative costs significantly lower than other instruments of social inclusion (Noteboom, 1987, Hanton, 2004). The UBI "would serve as compensation for diseconomies of small scale production and generate increases in scale, concentration and growth" (Nootebom, 1987). In advanced economies, the provision of a UBI would stimulate entrepreneurship by reducing the levels of personal risk, with an emergence of new innovative and creative business models.

However, the discourse on the UBI in political and academic circles has been inclined towards a macroeconomic and national approach (Widerquist et al., 2013). The disconnection between macroeconomic approaches to policy development and the study and implementation of solutions with objective impact at micro scale has been high, as has been the disconnection between UBI approaches and the proposals for new instruments in the field of innovation policy. It is assumed that basic revenues have to be paid (and, therefore, financed) by macro-structures like the national state,

> *When production and consumption are closer, more benefits and impact are generated*

from top to bottom, and that the political debate takes place at the national level. This diversion has been evidenced by the choice of names such as tax regime, state bonus, national dividend or citizen salary for the different variants and approaches to the UBI (Van Parijs, 2004, Fridman, 2013). Even so, if we start from the hypothesis of considering the UBI not as a mitigating instrument (pertaining to the sphere of social welfare and equality policies), but as an instrument of innovation policies, aimed at stimulating economic growth, then we arrive at a surprising conceptual construction: we argue that the UBI has to be provided at city or local community scale. Temporary innovation policies have followed an evolution from the national or supranational level to the local or urban level. From national, or continental, systems of innovation, to local systems. In this evolution, policies have changed their approach, from predominantly techpush dynamics to predominantly market-pull dynamics. The deployment of local policies, of a market-pull nature, responds to the closest needs of the citizen. Since innovation policy and even innovation and entrepreneurship are increasingly an urban phenomena (Cohen, 2016), it seems appropriate to review the mix of existing policies at local scale, extend the logic of innovation to logic of creation and distribution of wealth, identify the link between local innovation policy and local welfare policies, and place the UBI at the centre of this discourse. We argue that, under certain conditions (namely the local or urban approach) and the use of specific instruments (local currency), the UBI can become a driver of innovation and citizen welfare. When production and consumption are geographically closer, more benefits and impact are generated (New Economics Foundation, 2006). Providing the UBI at local scale would mean a new leap, from a customer-centred market innovation policy to a citizen-centred social innovation policy.

The evolution of innovation policies: towards local approaches

Alongside the intensification of global competition, the globalization of markets and the acceleration of technological chan-

ge, companies have undergone a greater strategic pressure to innovate, differentiate and obtain superior corporate margins that allow them to reinvest and grow. There is a broad consensus in the academic literature on the importance of knowledge, technology and innovation in economic growth and in the welfare of countries (Tödtling and Trippl, 2005). Nevertheless, the competitiveness of companies depends not only on their individual strategy, but also on the quality of the environment in which they compete (Portero, 1999). In this sense, the location in an innovative cluster facilitates the absorption of knowledge and good practices by companies. Thus, the actions of governments count on innovation: the innovative capacity of companies depends on the ability of governments to create institutional frameworks that encourage the emergence of innovative clusters and to make long-term policies and strategic investments to share and reduce innovation risk (Mazzucato, 2013).

Supranational or state innovation policy approaches have been developed implicitly under the linear R + D model: it is assumed that once new sources of knowledge are generated, this will be disclosed as a natural and spontaneous process towards the economy and society. The programs proposed at national or supranational level are tech-push programs, which generate large scientific or technological capacities. In general, they are large research programs, initiatives that are not concerned with stimulating the absorption capacity of companies (Tödtling and Trippl, 2005), and which are aimed at solving major technological, strategic or geopolitical challenges (many of them induced by logics of defence). These efforts have not been considered by a large part of the economic status quo, which conceptualized innovation as the pure result of market dynamics. The fact that the more orthodox conventional wisdom has questioned or neglected the real effect of public investments in R + D in the economy, Mazzucato (2013) demonstrates how the state intervention in the promotion of disruptive technologies (mainly, through long-term investments in specific strategic areas) is capable of creating technological competencies that, through the subsequent action of entrepreneurs, give rise to new generations of transforming products (see the case of the iPhone, which incorporates a set of twelve key technologies fully developed with public resources of the U.S. Government). According to Mazzucato, great transformative innovations such as mobile communications, GPS or Internet are spillovers of public R & D investments that are not market oriented.

Especially since the year 2000, with the famous Lisbon Summit, in which the EU Member States commit themselves to transform Europe into "the most competitive economy in the world based on knowledge", new approaches to innovation policies led from national and regional levels emerge. National innovation systems (NIS) are defined as "the network of public and private institutions within an economy that fund and perform R&D, translate the results of R&D into commercial innovations and affect the diffusion of new technologies"(Lundvall et al., 1988, Nelson, 1993, Mowery, 1994). The first approaches to the concept of NIS go back to the ideas of Friedrich List on "the national system of political economy" (1841), which proposed a series of systemic measures (of the set of agents of the economy) to accelerate the technological change in Germany at that time, concerned about the emerging English economic power since the first industrial revolution (Freeman, 1995). The progression of innovation policy research in the 90s shows evidence that the acceleration of technological change and the economic growth of nations depends more on the diffusion and efficient adoption of innovations than on leadership in the generation of new disruptive knowledge (Freeman, 1995). The case of the USSR is paradigmatic: a leading nation in its time in mathematics, physics and aerospace technology was absolutely inefficient in converting this frontier science into economic growth and welfare for real citizenship because of the lack of an adequate institutional framework of interconnection between agents and economic incentive systems to make innovations reach the end user. Innovation is not a linear process that depends on brute force in R + D, nor on isolated tech-push dynamics. Innovation has a systemic and evolutionary character (Edquist, 1997) and requires intense communication and interaction between groups of agents (companies, entrepreneurs, universities, financial institutions and public bodies). Innovation is a phenomenon of proximity and interaction between technological capabilities and the needs of the market. The type of interactions and information flows that generate successful innovations are especially efficient in physical proximity (Boschma, 2005). Thus, while the development of pioneering scientific knowledge capable of generating a flow of disruptive technologies is triggered by global, supranational or national dynamics, its efficient conversion into commercial competitive advantages occurs in the proximity, in local environments, and in close contact with the clients.

Since the late 1990s, academics have given increasing importance to sub national regional and local approaches to innova-

tion policy (Ratti et al., 1997, Autio, 1998, Cooke et al., 1997). Since 2000, the European Commission itself established the region as a valid analysis unit in innovation policies, for its theoretical historical, cultural and business homogeneity; and urged the Member States to implement regional innovation strategies (RIS) based on the intelligent specialization at regional level. In fact, regions have an essential role in the coordination and implementation of policies (Morgan and Cooke, 1998).

Nevertheless, regions are often artificial entities, defined by political institutions, and borders are generally determined by history. They are not necessarily homogeneous economic realities and their validity as a unit of analysis in the competitiveness policy has been widely criticized for their possible heterogeneity (Lagendijk, 2004). Before the emergence of the RIS concepts, Porter (1990) introduced the concept of cluster as a "geographic concentration of interconnected companies and institutions operating in the same sector of the economy". The clusters respond to another theoretical framework and to a geographic scope generally inferior to the RIS or NIS approaches. Business concentrations are pre-existing economic phenomena, independent of administrative divisions, which often define policies according to political criteria. These concentrations are generally local, and are revealed as optimal environments for the diffusion of innovations, cooperation between companies and interaction and dialogue with administrations. The clusters are especially appropriate for the development of innovation and competitiveness policies of SMEs because of the cultural and strategic homogeneity of the companies. The concepts of the cluster of Michael Porter and its models of competitive forces have been widely used by regional and local public administrations to boost the concentrations of SMEs, but also to encourage high-tech companies and accelerate the emergence of innovation districts in urban areas or high technology areas (Keeble and Wilkinson, 2000).

Finally, the success of the innovative process also depends on the experience and expectations of the consumer, forgotten in all the tech-push / top-down approaches to innovation policies. The dynamic market-pull is decisive in the efficient conversion of new knowledge and ideas in products and services. As innovation becomes more and more a collaborative and open process, its success depends on efficient interaction with users (Morgan and Cooke, 1998, Chesbrough, 2003). Social capital and tacit knowledge of the market are a key factor in obtaining good results in the introduction of new products and

> **The unit of analysis in innovation policy has progressively moved to the local and urban level**

services (Morgan and Cooke, 1998). Sub regional spaces (cities and urban environments) are the optimal spaces for interaction with the user. The tacit knowledge (non-codifiable) is transmitted in the short distance, in the face to face. This allows a more local approach to innovation policies. In recent years, the unit of analysis in innovation policy has progressively moved to the local and urban level. In this way, a national or national innovation system is made up of different clusters, innovation districts and local innovation systems, which form autonomous learning units (Muscio, 2006).

The design of local policies to support innovation continues to be an active and still unresolved debate among the academic community (Beaudry and Schiffauerova, 2009), especially regarding the dialectic between homogenization and diversity: what is better, the cluster of local specialization recommended by Marshall (1890) and Goalkeeper (2003) or the diversity benefits of pioneering urban environments by Jacobs (1969)? Nylund and Cohen (2016) agree with Jacobs and introduce the construction of collision density, relative to the urban advantages that allow a high frequency of interdisciplinary interactions among several innovation actors in high concentration areas. Regardless of the paradigmatic differences in regulatory approaches to foster the growth of urban innovation and entrepreneurship ecosystems, at least three factors have converged to accelerate local change: the massive urbanization that is being produced all over the world, the growing collaborative character of innovation among entrepreneurs, corporations, universities and local governments, and the democratization of innovation and entrepreneurship tools (3D printing and fab labs, co-work spaces, crowd funding, cloud computing and more), which are highly accessible in high urban density environments (Cohen, 2016).

The collaborative character of innovation and the emergence of local innovation systems have generated new concepts and tools for testing, interacting and experimenting new technologies with the end user (smart cities, living labs, spaces of collective work, workshops maker) to capture the tacit

knowledge of users, encourage their interaction and reduce the barriers of entrepreneurship to urban areas. Citizen innovation and the capacity of public bodies to generate new services aimed at improving the quality of life of citizens has grown in recent years as the political community deploys tools such as contracting for innovation (public purchasing) (Edquist and Zabala-Iturriagagoitia, 2012), civic crowd funding and citizen entrepreneurship programs (Muñoz and Cohen, 2016).

Then, since their conception, innovation policy approaches have evolved from tech-push logic to market-pull logic; from top-down designs to collaborative and co-creation designs with the user; from supranational perspectives to local perspectives, and from economic growth objectives to needs for inclusive growth. At the same time, the UBI approaches have

gone from logical, mitigating and social welfare to logics of stimulus instruments of demand, innovation and entrepreneurship. The point of convergence, then, seems conceptually clear: our hypothesis is that the UBI has to be identified as an instrument of innovation policy and must be placed as the culmination of a new generation of urban or local innovation policies, market-pull and cooperatives, with a final recipient who stops being the consumer to become the citizen.

Conclusions and future lines of research

To close the discussion, we are missing a pragmatic debate on the implementation of the instrument. We suggest starting prospective research on the following idea: provide the UBI in local digital currency. The provision of resources in the form of local currency stimulates local employment, increases salaries

Table
Innovation policies according to its scope

Scope	Tools	Underlying driving forces	Objective	Beneficiaries	Types of innovation dynamics
Global	Scientific networks	Scientific rationality	Creation of knowledge	Humanity	Tech-push
Supranational	R & D framework programs (Europe) Long-term technology plans (US, Russia, China)	Technological innovation	Defence Technological leadership Industrial leadership	Political system	Tech-push
Global	National agencies (DARPA, NASA, TEKES, MATIPMOP) Technology Infrastructures (Fraunhofer, Catapult) Tax Policy Financing in industrial R & D (grants and loans) Public procurement Industry regulation	Technological innovation Economic freedom	National growth	National Competitiveness Large Companies	Tech-push
Local	Cluster policy Smart specialization University technology transfer	Economic freedom	Regional growth Competitiveness of SMEs	SMEs Clients	Market-pull
Regional	Living labs, Innovation districts Smart cities Incubators and accelerators Maker movement **Local universal basic income**	Democracy	Promotion of entrepreneurship Improve the life of citizens	Entrepreneurs Citizens	Market-pull

and social capital (Schussman, 2007). The currency is a socially constructed institution that can be modulated to create the right incentive system to stimulate economic growth in specific communities (Seyfang and Longhurst, 2013). Local currencies have already been used to provide liquidity in poor areas (Slay, 2011). The local currency has a multiplier effect when it circulates in a closed environment, with no possibility of escape, creating specific richness in the local context. It would stimulate consumption and local production, since for some authors "the most rational way to produce is to provide local resources for local needs" (Schumacher, 2011, Jacobs, 2016). The key elements to ensure basic levels of life, housing, food, energy, water, transport and education, among others, are mainly given and have local experience. There are academic trends who claim to reorganize economic structures to respond to local needs (Swann and Witt, 1995). A UBI in the form of a local currency would have the double virtue of eliminating poverty and generating local wealth at the same time, stimulating local demand (in a similar way as innovative public purchasing actions stimulate the supply of local innovation). The local currency does not substitute, but complements the national currency and solves the problem of the autonomous lack of sustainability of the communities, at least in terms of wealth generation (Douthwaite, 1996 and 2012). Finally, alternative currencies such as crypto currency (for example, bitcoin or ethereum), local paper currencies and timebanks have grown in recent years as a response in part to the growing financing of national and supranational economies (Cohen, 2016).

In this article we propose a revision of an emerging instrument (the UBI) within the framework of innovation policies, as a measure to eliminate poverty and simultaneously generate economic growth. We suggest a conceptual formula to solve one of the problems of modern innovation policies (inequality), specifying the scope of implementation (at the urban scale) and the potential mechanism (local currencies). If wealth accumulates in a small number of large global digital platforms and growing trends towards automation continue, the large decoupling between labour productivity and income and labour growth documented by Brynjolfsson and McAfee (2014) is likely to grow in the future. This article creates a theoretical framework for the confluence of innovation policies and social welfare policies, and conceptualizes UBI as the mechanism that induces economic growth and corrects inequalities. We have omitted the connection of the microeconomic formula with the macroeconomic monetary system. Additional research on local currencies and UBIs is needed to analyze the impact of these measures at macro scale. ■

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BLOCK III

THE CATALAN INNOVATION AND SCIENCE SYSTEM: REALITY AND POTENTIAL

CONCLUSIONS AND PROPOSALS: KEY IDEAS OF THE 3RD CATALAN ECONOMY AND BUSINESS CONGRESS

The great challenge is to transform the Catalan research and innovation system, basing on:

- making the research system more competitive on a global scale;
- accelerating the arrival of research results in the market;
- improving the economic and social impact of innovation;
- using the entrepreneurial impulse of the ecosystem; and
- taking more advantage of the Barcelona brand.

1. As a result of the crisis and European policies, it has been noticed that an economic model of competitiveness based on cost reductions poses a risk to the attraction of talent and investment in innovation. We must look for:

a. a model based on added value, rather than on the reduction of resources invested in the system; and

b. promoting demand policies that favour research and innovation despite seeking to meet the European deficit targets.

2. If we want a country that is a benchmark in innovation, we need a Government that leads it transversally and practically, therefore:

a. it is necessary for the Government to adopt a role of innovative leader beyond direct helps;

b. we need a system with a more focused direct stimuli;

c. the management and contracting mechanisms for research and innovation must be made more flexible; and

d. enhance and improve the magnitude of flows between agents of the system.

3. Due to the economic crisis and the new political and economic paradigm, the Catalan research model has to evolve to survive in an environment that is more global and competitive:

a. less system agents are needed, but stronger and more competitive at international level;

b. we must accelerate a concentration of agents in the system, select the most effective ones and concentrate our efforts on the best;

c. pose more emphasis and incentives in the transfer of knowledge; and

d. we must have a more integrated research and innovation system.

4. The Catalan university system has played a relevant role as an agent of the research system, despite the fact that there is a serious gap of transfer to society that must be amended soon:

a. it has to be better explained to society that what universities do has an impact and is relevant;

b. the legal framework must be relaxed and changed in order to encourage the university to be closer to the market and more entrepreneurial;

c. it is necessary to define incentives and mechanisms that promote the scaling up of research results in the industrial sphere; and

d. it is necessary to professionalize the transfer offices and improve the service to the external client.

5. The Catalan patent system is deficient in the sense that not many are requested and they are of poor quality. If the Catalan company is to improve its competitive positioning on a global scale, the patent system must be strengthened.

6. The private sector has concentrated investment in innovation in just over 1% of Catalan companies:

a. it is necessary that most of the companies invest in innovation in a more determined way; and

b. look for a bigger collaboration with the Catalan research and innovation system to ensure its competitiveness and growth.

7. Diversity is key to favour a good innovation and, in this sense, we need to:

a. actively promote the role of women in the Catalan research and innovation system;

b. attract more women to technological positions; and

c. promote multiculturalism.

8. The Barcelona brand is powerful and highly positioned internationally; it is associated with design, creativity, management, training and innovation and we must look for ways to leverage the innovation system on this brand. ■

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