PAPER

Title: Clustering of Cultural and Creative Industries

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Abstract:
The investigation of the spatial distribution of firms has always been of interest for economists and policy makers. Research in this area starts from identifying certain spatial patterns to providing a range of rationalizations on their determinants or implications, which helps uncovering what is hindered beyond the development of cities among other assorted economic and social phenomena. Such studies are still preliminary when it comes to Cultural & Creative industries, the field in which the interest in has been growing in the last decade. The purpose of this paper is to identify

the spatial distribution preference and clustering, if any, of firms in CCIs from a general perspective and then at industry level, in Catalonia. The study uses firms' data from Mercantile Register (SABI).

Keywords: *creative industries, clusters*
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1. Introduction

Anyone in the world would like to visit *hub* cities, whether it is Barcelona, Paris, Milan, London, New York or places as such. Those cities attract individuals and firms, leading to the formation of clusters in wide range of sectors: financial or other services, manufacturing, research and development, software, and many others. Clusters do benefit the economy; one general statement that has been concluded over the last decades, leading researchers to figure out the spatial distribution of firms, the natural determinants and the possibility for induced ones in response to the advantages and positive spin-offs that clustering in various industries provides. The concept of a *business cluster* is by no means new to the academics, being introduced in the studies of Marshall (1990) and termed by Porter (1991). More recently, the literature on economic geography started to cover the cluster dynamics and determinants ranging from agglomeration and urbanization effects, and tracing influence on local development in cities of developed nations.

The investigation of the spatial distribution of firms has always been of interest for economists and policy makers. Research in this area starts from identifying certain spatial patterns to providing a range of rationalizations on their determinants or implications, which helps uncovering what is hindered beyond the development of cities among other assorted economic and social phenomena. Such studies are still preliminary when it comes to Cultural & Creative Industries (CCIs), the field in which the interest in has been growing in the last decade. The purpose of this paper is to identify the spatial distribution preference and clustering, if any, of firms in CCIs from a general perspective and then at industry level, in Catalonia. This study is a milestone that furnishes the ground for studies on the determinants of the spatial patterns which can be access to other firms on industry level, consumer demand, agglomeration economies, urbanization or human capital.

Within the creative industries literature, numerous concepts have been developed, starting from the classical classification of CCIs provided by the DCMS to the clear policy-making definitions of the *creative economy* addressed by the UNCTAD and the OECD, the *creative class* by Florida (2002), *creative cities* (UNESCO, 2012; Pratt,

2010; Evans, 2009), *creative milieu* (Coll-Martínez and Arauzo-Carod, 2017) and more recently the *creative clusters* (Lazzeretti et al., 2012; Boix et al., 2012; Stern and Seifert, 2010; Mommess, 2004), which are the focus of this study.

So, what about creative clusters of CCIs? Do firms within those sectors have a special pattern of spatial distribution? Do they behave in this sense similar to other industries? Or they hinder some different prototype? And in any case, what are the determinants beyond their specific distributions, if any? Boix et al. (2012) argue that the geography of creative industries is *diverse*, *heterogeneous* and *complex*. In a similar way, Power and Hellencreutz, 2005 (p:1) argue that "cluster-inspired economic development strategy can be valuable in relation to the cultural industries and to rural or peripheral areas". Understanding creative clusters is fundamental for the design and implementation of policy-making (Boix et al., 2012) and creative firms' entry strategies. In this study, we attempt to establish an understanding in the spatial patterns of CCIs in Catalonia. As this step is fundamental for starting to comprehend the dynamics of those industries, and *within* those industries, this study rests in the heart of evolutionary economic geography, applying a new methodology to provide a key understanding in this aspect.

In the last decade there has been a rising understanding that cultural and creative industries such as music, fashion, publishing, film, media, research and development and software design are significant economic contributors to developed countries in terms of innovation, local development and employment growth (OECD, 2018). As well, there has been an increased attention in those countries in developing and sustaining the cluster approach, mainly smart specialization strategies as a tool for regional development, as evident from recent initiatives by the European Commission and OECD to foster better innovation strategies led by clusterisation patterns that create new urban economically-productive and innovative locations. Bagwell (2008) states that the focus now is on selective business clusters which are seen as capable of helping local economic development and job creation. A rising body of empirical literature is reflecting on the advantages and economic potential of clusters. Delgado et al (2015) argue that "clusters have positive impact on regional and industry performance, including job creation, patenting, and new business formation which calls for the need

for cluster-based data to support research, facilitate comparisons of clusters across regions, and support policymakers and practitioners in defining regional strategies". In a critical literature on creative industries geographic evolution, Berg and Hassink (2014) argue that there an urge for empirical examinations which tackle questions related to the co-evolution of creative industries using evolutionary economic geography concepts among which they emphasize the clear need to understand the spatial dynamics of creative industries, what are their determinants and the differences between the co-evolution of creative industries and other industries.

With this being said, and clusters' planning in CCIs accumulating primary attention in policy-making agendas, we aim to understand in this study on the spatial distribution of CCIs in the metropolitan area of Barcelona. It is noteworthy to mention that CCIs play an important role in Catalonia in terms of economic and social positive externalities. Accordingly, the purpose of this study is to analyze spatial distribution of firms belonging to Cultural and Creative Industries in order to check their clusterisation patterns both in general terms (for CCIs altogether) and at industry level, using firms' data from SABI in Catalonia (we have CCIs' firms geo-located).

This study is exploratory in nature. We ask the following research question: Do cultural and creative industries cluster in the core or periphery of Barcelona? And if any preference exists, is it common among all sectors or are different spatial patterns taking place between them? Have those patterns changed between 2009 and 2017? Is there a specific urban resilience supporting CCIs clusters?

The structure of this paper is the following. Second section reviews literature and addresses main points raised by scholars on cultural and creative industries, their spatial distribution and clusterisation patters, third section provides the theoretical framework of the study, the fourth section details characteristics of dataset and provides some descriptive statistics, fifth section describes methods for cluster identification and discusses main results, and sixth section concludes and indicate directions of further analyses.

2. Clustering, Cultural and Creative Industries, and the linkage

A basic definition to start with is that on clusters provided by Michael Porter (2008, p. 75) to explain the competitive advantage of regions and nations, in his book *On Competition:* "*A cluster is a geographically proximate group of interconnected companies and associated institutions in a particular field, linked by commonalities and complementarities*."

Numerous benefits rise from the co-location for firms explained in theory of market pooling introduced by Marshall (1920) and then further economic geography investigations of clusters in the modern economic contributions. Marshall argues that co-location allows firms to share skilled labor, reduce inter-firm transaction costs and generates knowledge spillovers (Marshall, 1920). Porter further elaborated on the benefits of innovation, sustainability and learning opportunities of firms that increases their productivity and competitiveness. More recent literature emphasizes the importance of clustering and its ability to generate numerous gains for firms, cities, or even rural/periphery areas in which they exist and sustain, among which are the following: encouraging regeneration of underprivileged areas, enhancing productivity and competitiveness, stimulating entrepreneurship, boosting economic growth through employment growth and innovation among other positive knowledge spillover effects (Delgado et al., 2015; Boix et al., 2012; Hesmondhalgh, 2008; Porter, 2008, Mommaas, 2004). Ellison et al. (2012) argue that proximity reduces transport costs. This makes the concept of creative clusters' development vital within economic strategies for local and regional development within the EU countries and other developed nations.

Cultural production clusters in relatively few places, namely large urban cities. In the late 1990s the development of cultural industries, becoming a concern for policy-makers, caused the adaptation of the term by connecting it to the growing "cult" of creativity and using the term "creative clusters" to become inclusive of both cultural industries and creativity-led occupations within management processes and businesses (Hesmondhalgh, 2008). The terms cultural clusters and creative clusters have been used interchangeably in some studies. Stern and Seifert (2010) define cultural clusters as geographic concentrations of creative sector producers and consumers and argues that such clusters have positive impact on cultural production and the interaction of cultural and creative entrepreneurs. It is noteworthy to mention the differentiation between

cultural clusters on one hand and cultural districts on the other, as provided by Stern and Seifert (2010), the first represents the geographic concentration of producers which creates positive knowledge spillovers resulting from the accumulation of specialized services, while the second represents the consumption cultural clusters which are more into tourism and hospitality. Furthermore, the authors emphasize the cultural clusters' social and economic benefits in terms of spurring civic engagement as the arts generate participant networks that span 5on-profit5od boundaries, overcoming barriers of social class and ethnicity that circumscribe social interaction. The authors introduced the Cultural Asset Index (CAI) to identify cultural clusters. CAI aggregates data on cultural participants, resident artists, 5on-profit cultural organizations, and commercial cultural firms, all incorporated into a geographic information system and aggregated at the census block group level.

Mommas (2004) emphasizes the role of cultural and creative clusters as urban regeneration resources, in addition to providing additional-despite being debatable-benefits such as the promotion of cultural democracy, place-marketing which boosts tourism and attractive labor force leading to higher employment, boosting entrepreneurship, re-using of old buildings, and having an indirect and induced effect which can be reflected in the creation of other entertainment and leisure activities aside cultural and creative ones. This goes in line with the literature which argues for the benefits of creative clusters in attracting employment and entrepreneurship-and not necessarily within the CCIs themselves- where people are looking for a more entertaining lifestyle.

Zheng (2011) investigate the relationship between creative industry clusters and the formation of entrepreneurial urban features based on a cultural approach. The authors argues that creative industry clusters serve to promote an image or reputation for a city or region by providing niche markets as great places to live, work and play so as to attract tourists and investment ranging from flagship cultural infrastructure to leisure venues and promotion of cultural tourism and development of local identity which leads to creating entrepreneurial urban landscapes.

Aside the benefits of creative clusters, another segment of literature explains the determinants of the spatial clustering of creative firms. De Vaan et al. (2012) state that most economic geographers explain the spatial clustering as a result of localization externalities stemming from co-locations within the same or linked industries. In a comparative study between Italy and Spain, Lazzeretti et al. (2008) address the spatial distribution of cultural and creative industries using the creative local production systems (Creative LPS) as their unit of study which measures the specialized employment in creative industries in general and captures their diversification among traditional and non-traditional creative industries following Lazzeretti (2007). Among their major findings on the aspect of spatial distributions, the authors argue that in both countries the creative industries are likely to cluster in largest urban agglomerations, however, this phenomena is more concrete for the case of Spain where the clusters are accumulated in "5-6 metropolitan areas of the country" (mainly the metropolitan areas of Madrid and Barcelona where the relevant LPSs accumulate for 45% of Spanish employments in CIs) (p. 21). Referring to their study, the case of Italy, despite the observation of urbanization inclination among creative clusters, yet, there is an obvious distribution among the whole country and the clusters are smaller in nature, especially when investigating the differences between traditional and non-traditional ones.

In a similar study, using local labor markets in France, Great Britain, Italy and Spain, and based on the same methodology of differentiation between traditional and non-traditional clusters, Boix et al. (2012) find that (1) creative industries are highly concentrated, (2) the concentration is most common in big cities leading to the formation of hubs, (3) by ranking, the most visible creative clusters are formed in London, Paris, Madrid, Milan, Barcelona and Roma, with differences of concentration levels between the cities, (4) medium cities as well feature some form of concentration of local creative systems, and (5) unlike other countries tested in their study, non-traditional creative industries are more important in Great Britain.

2.1 Determinants of Creative Clusters

Why firms in the creative industry do cluster is a question that has been asked by a number of researchers in the field. Creative industries are diverse and cluster and prosper in response to distinctive knowledge base and characteristics of each

community (Wu, 2005). On a general note, common determinants for clusters to start with, as derived from preceding literature are the following:

1. Cultural heritage including historical place, monuments, civilizations' ruins (Lazzeretti et al., 2012; Cooke and Lazzeretti, 2008; Mommaas, 2004)
2. Universities and knowledge transfer (Goa et al, 2010; Eun et al., 2006; Wu, 2005)
3. Localization externalities (Lazzeretti et al., 2012)
4. Urbanization economies (Lorenzen and Frederikson, 2008)
5. Creative Class (Florida, 2002)
6. Spin-offs dynamics (Gong and Hessink, 2017; De Van et al., 2012)
7. Public intervention and supporting institutional *milieu* (Foord, 2009) governmental regulation in the form of local, regional and national frameworks which affect spatial patters of creative firms (Wu, 2005; Turok, 2003)

A detailed systematic literature on clustering of creative industries was recently provided by Gong and Hessink (2017). Among the major determinants of clustering, the authors first emphasize the role of agglomeration economies relevant from localization economies (concentration of production, high degrees of specialization, co-location of creative firms, and local knowledge spillovers), or urbanization economies (concentration of creative industries in cities, "quality of place, instead of "Access to place) (Glaeser et al, 1992; Florida, 2002). The authors then discussed the role of what they called "spin-off" activities, which we can interpret as subsidiaries, by-products, and by-services resulting from universities and parent corporates and can form a major reason for the clusterization of creative firms. Examples can be research centres of universities, software design companies near universities with active faculty in computer science engineering, as well as corporate subsidiaries agglomerating near parent firms.

A study by Goa et al. (2010) emphasizes the role of Tongji University in Shanghai in the clustering of architecture design firms in that area, a significant example about knowledge-transfer within knowledge intensive services, resulting from the presence of the university. Other examples are presented in the work of Wu (2005) for the World Bank on the dynamic cities and creative clusters. Wu describes how academia and local

business clusters can interrelate. Among the example he provides we may highlight (1) San Diego's biotech R&D cluster resulting from the University of California at San Diego Scripps Research Institute and the Salk Institute presence in that area, (2) Boston's Research Row-MIT, Harvard and other local universities- playing a role in the growing concentration of start-ups and R&D firms providing cutting-edge research and innovative solutions for many customer problems throughout the world, and (3) Fashion clusters in New York where he sees a sound local impact on university-based innovation and entrepreneurship in the city.

Lazzeretti et al. (2012) use an exploratory econometric model to quantify and assess the reasons beyond creative clusters in Italy and Spain, focusing on agglomeration economies, cultural heritage, institutional dimension, creative class and related variety. The authors reveal mixed findings between the two countries. The authors find that (1) the effects of cultural heritage, localization and urbanization forces are more balanced in Italy, whereas in Spain the effects of urbanization economies and the talent clearly dominated localization economies and cultural forces (2) relevant to their results on related variety, the urbanization economies are a relevant factor, nurturing related variety, especially in creative industries, but have a different performance depending on the country.

Turok (2003) emphasizes the role of institutions in the development of creative clusters, arguing that it is not a story of localized networks or clusters of small knowledge intensive firms generating regional growth through an endogenous process, contrary to the image conveyed by policy-makers and advisers. The strong demand created by national organizations benefiting from internal scale economies and regulated by the government is far more important. Similarly, Foord (2008) investigate the cases of Barcelona, Berlin and London in terms of spatial concentration across creative industries. The author reveals that there is a big role played by the participation of public and private institutions for developing creative clusters. However, he reflects on the need for future creative strategies to have a more sophisticated and realistic consideration of the role of the creative industries within the knowledge economy, including a deeper understanding of the innovation and production linkages between the

creative industries and other sectors of the (not-so-new) knowledge economy. As well, more attention needs to be paid to the particularities of locality.

On the other hand, De Vaan et al. (2012) find that spin-offs dynamics are a more important determinant in explaining creative clusters than localization externalities are, emphasizing that creative firms not only benefit from their parent firms, but also from the knowledge spillover resulting from variety in employees' expertise and personal networks in creative clusters. Zarlenga et al. (2013) analyze the tendencies of culture to form clusters from the perspective of social dynamics, focusing on the area of Barcelona. The authors emphasize the importance of the sociology of art and classical sociology concepts related to community and association in understanding the formation of clusters and conclude that in Barcelona there are three forms of cultural cluster and that in each one there is a predominant interaction logic: bureaucratic, associative and community.

One other branch of the literature which cannot be disregarded is dealing with the *building* of clusters. Based on three case studies in Sweden (music, information and content design, and film), Power and Hellencreutz (2005) have outlined major common factors essential for building clusters and, accordingly, we can refer to as possible determinants of clusters (1) the existence of a regional competitive advantage and potential, and *not necessarily* to start from a large agglomeration of firms, (2) the existence of civic entrepreneurs and cluster motors, (3) the intervention of the public sector in terms of financing educational programs and vocational training and infrastructure for stimulating clusters, (4) place-marketing and cluster branding in order to better attract investments, public funding and entrepreneurs, (5) existing of places such as temporary cites, festivals, or permanent ones such as universities in order to have meeting places where knowledge can be exchanged, (6) creating fun social contexts and better quality of life to attract creative people, (7) the insurance of the upgrading of labor skills and competences to enhance competitiveness and maintain sustainability, and (8) the acknowledgement of the sector-specific conditions characterizing small firms or micro businesses.

Mommaas (2004) argues that creative clusters differ in their spatial patterns similarly to how they differ in their structure and characteristics from other industries. Differences can be in their orientation from production creative firms to consumption-leading creative firms, in their portfolio, both horizontally and vertically, their financing, spatial position within wider urban infrastructure and policy intervention strategic plans. As well, Europe INNOVA (2011) provide considerable notes on creative clustering arguing in their report that different cluster and location tendencies for different sectors of the creative and cultural industries can be also resulting from the different stages in the CCI value chain, providing that whereas production and manufacturing activities are the most regionally concentrated, consumer/end-user oriented activities are the least regionally concentrated. Clustering is evident among creative firms specialised in manufacture or publishing: games publishing, recorded media and film and television activities, publishing of software and music, news agencies, and manufacture of musical instruments, as well as cultural heritage-related institutions. On a final remark, and following the argument of Gong and Hassink (2017) it is further essential to consider the industrial specificity, interconnections between different drivers, external linkages of creative firms and comparisons between different location to better understand and explain the clustering of creative firms.

3. Data and Methodology

3.1 Data

Our main data source is the SABI database (*Sistema de Análisis de Balances Ibéricos*), from INFORMA D&B. Specifically, SABI collects data from the Spanish Mercantile Registry, where mercantile firms are obliged to deposit their balance sheets on an annual basis. SABI provides information on a large number of variables regarding these firms, including birth date, balance sheets, income, expense accounts, number of employees, industry at 4 digits level, sales and assets, and the georeferenced location (X and Y coordinates). Although SABI is the most usual source for studies of the location of economic activity in Spain, this database is about firms, not establishments, being that in case of multi-plant firms data refers to firms, not to their establishments, so in those cases SABI will provide the information in an aggregated way for the firm as a whole, using the location of the headquarter. Obviously, having disaggregated

information for all the establishments would allow a much more precise analysis, especially as regards the spatial distribution of economic activity. However, this bias is not presumed to be relevant given that, according to data from 2006, multi-plant firms in Spain are estimated at just over 1% of the total (Jofre-Montseny et al., 2018). Regarding time coverage, we include two years, 2009 and 2017. The first one (2009) is just after the economic downturn (2007) that pushed thousands of firms out of markets, whilst the second one (2017) belongs to the beginning of the economic recovery, although the number of firms was still lower than at the beginning of the period.

3.2 Industries

Providing a definition for cultural and creative industries is not an end in its self for this paper, nonetheless, it is a primary milestone to define the sectors involved. Previous studies concerned with definitions of CCIs have been evident in the academic work (see, among others, Lazzeretti et al., 2008; Lazzeretti 2013, Bakhshi et al., 2013) and governmental and institutional reports. The Department of Culture, Media and Sports was among the first to provide a concise definition for CCIs in 1998 which then evolved to a more inclusive definition in 2013 (DCMS, 2013), followed by definitions provided by the UNCTAD and more recently the Eurostat and OECD. In this study, we build on the prevalent definition of CCIs and we take into consideration the Catalan context of economic activities in addition to the rationale of this study which is quite exploratory and aims at addressing the "broad" range of CCIs. The details on CCIs along with their CNAE 2009 and CNAE 93 equivalence (adapted from the Spanish Statistical Office) are presented in Appendix 1.

Following up, an exploratory analysis is conducted to identify the spatial distribution of firms in the cultural and creative industries in the Functional Urban Area of Barcelona (FUA). First, the clustering of CCIs is identified in general terms (inclusive of the twelve sectors termed as CCIs: advertising; architecture and engineering; cinema, music, TV and radio; fashion; graphic arts and printing; jewelry, music instruments and toys; photography; publishing; research and development; software and video-games; writing, performing arts, visual art and craft; activities related to heritage) (see details in Appendix 1). Then, the spatial distribution of firms in each sector is identified

separately. In this way, the characteristics and uniqueness of each sector is taken into consideration.

3.3 Cluster identification: Methodology of the Scan-test

There has been a large amount of research in recent years into statistical methods for identifying localized clustering. The Scan-test (Kulldurff, 1997) is probably the most frequently test used in epidemiology to identify cluster of diseases but has been used in a huge of fields of study. In the field of economy several contributions has been publish in last years with the objective of identify firms clusters (Kang, 2010; Kosfeld, Eckeyand Lauridsen, 2011; Scholl and Brenner, 2014; Murray et al., 2014; López and Páez, 2017).

The procedure of this test is based in the concept to impose a window on the map and move the window centre over each point location so that the window includes different sets of neighbouring points at different positions. By adjusting the centre location and the shape, the method generates a large number of distinct windows, each including a different set of neighbouring points. At each point location, the size of the window is increased continuously from '0' to a user-defined maximum size. The Scan-test looking for the windows were there is maximum difference between inside and outside of the window. In the case of our research the null hypothesis is that in all locations (census track) the probability of find a CCIS firm is the same while the alternative hypothesis is that there exists a window Z (a set of connected regions) such that the probability find a CCIS firm is higher inside Z than outside Z. Now we will introduce some notation, which is needed to follow the mathematical description of the test.

3.3.1 The Scan-test

Let N be the total population observed in the study region G, which is the sum of the population in each geographic unit such as county, state or census track (N_i, i =1,…,R), where 'i' indexes the geographic units in G and R is the total number of geographic units in G. Similarly, we use n and n_i (i =1,…,R) to denote the total number of cases in the whole country and in the geographic units 'i', respectively. Under the null H_0we suppose that the number of cases in the region 'i' namely N_i follow a binomial $B(n_i,p_i)$ distribution that we can to approximate to a Poisson $N_i=P(\lambda_i)$ distribution with $\lambda_i=n_ip_i$. Under the alternative suppose that there is a set of regions Z inside of the global region G where the probability of find a CCIS firm is different. Formally,

$$H_0 : \lambda_i = \lambda \quad \forall i \in G$$
$$H_A : \exists Z \in \Theta \text{ where } \lambda_i = \lambda_Z \text{ if } i \in Z;\ \lambda_i = \lambda_{\bar{Z}} \text{ if } i \in \bar{Z} \tag{1}$$

the likelihood ratio depend of the set Z

$$\lambda_Z = \left(\frac{N_Z}{E_Z}\right)^{N_Z} \left(\frac{N - N_Z}{N - E_Z}\right)^{N - N_Z}$$

where N_Z is the total of firms in the set Z and E_Z is the expected number of CCIS firms under the null. The Scan-test looking for the set Z, where the ratio of likelihood is maximum. Therefore, the Scan-statistic is defined as,

$$\text{Scan} - \text{test} = \sup_{Z \in \Theta} \lambda_Z = \sup_{Z \in \Theta} \left(\frac{N_Z}{E_Z}\right)^{N_Z} \left(\frac{N - N_Z}{N - E_Z}\right)^{N - N_Z} I\left(\frac{N_Z}{E_Z} > \frac{N - N_Z}{N - E_Z}\right)$$

where I(x) is an indicator function. This indicator function can change if the objective is looking for a cluster of low incidence of CCIS firms (changing '>' by '<') or delete if not assumption is considered. Θ is the set of all possible connected regions which could be considered in the study area. Typically in practice, this set Θ is reduced to only circular and/or elliptic shapes, though it is also possible to work with spatial clusters of flexible shapes (Tango, 2005). The region Z* where the likelihood ratio reach the maximum, is named Most Likely Cluster (MLC). If the MLC is significant, the process is repeat looking for secondary clusters non-overlapping with the MLC.

The theoretical distribution of the Scan-statistic under the null hypothesis is not known. For this reason, its significance is evaluated numerically by simulating neutral landscapes (obtained by means of a random spatial process) and comparing the empirically computed statistic against the frequency of values obtained from the neutral landscapes. Hence, a p_B-value is obtained through the Monte Carlo hypothesis testing method, by comparing the rank of the maximum likelihood functions of the real dataset with the random data sets, with a number *B* of replications. This tests have been well received both by the simplicity of the technique, by the power of contrast and the implementation of free software http://www.satscan.org/ for computing propose

3.3.2 Secondary clusters

The Scan-tests are based on statistics obtained under the alternative hypothesis of a single cluster (with a known form and size). If the test rejects the null hypothesis and

identifies a significant cluster, a natural question would be to ask if there is another cluster, not overlapping with the most likely cluster, the variance of which is significantly different from the rest. These clusters are the so-called secondary ones. There are several ways to assign *p*-values to secondary clusters, see the paper of Zhang et al. (2010) where several alternatives are presented. The standard approach consists of ordering all the elements of Θ according to the likelihood ratio from highest to lowest. The most likely cluster (hereinafter MLC) will be the one that takes the maximum value. It will be assigned the *p*-value corresponding to the percentile that corresponds to the likelihood ratio in the distribution obtained by permutational resampling. The first secondary cluster will be the one that takes the maximum value within those elements of Θ that do not overlap with the MLC, assigning the *p*-value corresponding to the percentile that occupies the distribution obtained by permutational resampling. The procedure continues until no non-overlapping clusters are found statistically significant at a level (1-α)%. Zhang et al. (2010) show that this procedure yields conservative *p*-values.

Therefore, they suggest an iterative method that consists of eliminating from the sample the observations included in the most probable cluster and re-obtaining the value of the statistic with this sub-sample once the cluster has been eliminated and all the statistically significant secondary clusters identified by this iterative process. Zhang et al. (2010) confirm that this procedure offers more power to identify secondary clusters. This will therefore be the method used in this paper.

4. Results

4.1 Descriptive Statistics

This section provides some descriptive statistics on the CCIs and their sectoral disaggregation regarding total number of firms in CCIs, their percentage of total firms and reveals each of the sectors' growth patterns for two years 2009 and 2017.

Table 1: Number of Firms in the Functional Urban Area of Barcelona (2009 and 2017)

Industry/Year	**2009**	**Sectoral% from CCIs**	**2017**	**Sectoral% from CCIs**
Advertising	1,769	16.6	1,412	16.1
Architecture & Engineering	2,239	21.1	2,215	25.2
Cinema, Music, TV and Radio	865	8.1	693	7.9

Fashion	1,068	10.0	526	6.0
Graphic Arts and Printing	1,565	14.7	1,106	12.6
Jewelry, Music Instruments and Toys	377	3.5	279	3.2
Photography	271	2.5	181	2.1
Publishing	854	8.0	588	6.7
Research and Development	147	1.4	223	2.5
Software and Video-games	976	9.2	1,123	12.8
Writing, Performing Arts, Visual Arts and Craft	461	4.3	396	4.5
Design	0	0.0	0	0
Activities Related to Heritage	44	0.4	33	0.4
Total CCIs	**10,636**	**100.0**	**8,775**	**100.0**
Total Firms (All Industries)	**130,313**	**--**	**98,422**	**--**
%CCIs from Total Firms	**8.16**	**--**	**8.92**	**--**

Source: own elaboration.

In this sense, Table 1 shows how distribution of CCI firms in terms of industries between the two years considered (2009 and 2017) is quite similar, but for the important growth achieved by Software and Video-games firms (from 976 to 1123), that contrasts with the contraction of the whole industry in the same period (from 10,636 to 8,775).

Table 2: Descriptive Statistics of Sectors' Number of Firms

	Mean	**Median**	**Range**	**Min**	**Max**	**Standard Error**	**Standard Deviation**	**Skewness**
Advertising	1188	1412	1386	383	1769	416	720	-1.26
Architecture & Engineering	1853	2215	1134	1105	2239	374	648	-1.72
Cinema, Music, TV and Radio	1373	865	1867	693	2560	596	1032	1.67
Fashion	827	887	542	526	1068	159	276	-0.93
Graphic Arts and Printing	905	1106	1522	43	1565	451	781	-1.08
Jewelry, Music Instruments and Toys	319	301	98	279	377	30	51	1.38
Photography	3141	271	8790	181	8971	2915	5049	1.73
Publishing	638	588	382	472	854	113	196	1.07
Research and Development	700	223	1584	147	1731	516	893	1.71
Software and Video-games	1233	1123	624	976	1600	188	326	1.34
Writing, Performing Arts, Visual Arts and Craft	601	461	551	396	947	174	301	1.64
Design	286	0	859	0	859	286	496	1.73
Activities Related to Heritage	99	44	196	33	219	60	104	1.71

Source: own elaboration.

As explained before, the analysis is conducted for two years (2009 and 2017) in order to control for both temporal continuity of clusters and potential bias caused by fluctuations in business cycle due to the economic downturn between 2007 and 2014. Next we show results for cluster analysis for each one of these years (Table 3 for 2009 and Table 4 for 2017) in which tables refer to number, size (in terms of number of firms) and

significance of clusters (scan statistic), taking into account that only significant clusters (with p-values <0.05) are included, whilst figures show graphically location of clusters.

Table 3 Cultural & Creative Industries (Clusters-Ellipsoids at 10%) Year 2009

Industry	Nb	Size	Nz	Nf	ENf	Nf/ENf	T-Stat	P_Value
Cultural & Creative Industries	1	8	1,229	248	101.8	2.4	75.7	<0.001
	2	124	12,944	1,345	1072.0	1.3	34.0	<0.001
Advertising	1	131	12,971	297	176.1	1.7	38.3	<0.001
	2	156	10,818	216	146.9	1.5	15.7	<0.001
Architecture & Engineering	1	237	11,584	288	199.0	1.4	16.8	<0.001
Cinema, Music and TV	1	118	13,004	173	86.3	2.0	36.4	<0.001
	2	6	1,386	45	9.2	4.9	34.3	<0.001
Fashion	1	94	3,920	130	32.1	4.0	88.6	<0.001
	2	1	168	28	1.4	20.3	58.1	<0.001
	3	5	568	20	4.7	4.3	13.6	0.005
Graphic Arts & Printing	1	32	1,168	51	14.0	3.6	28.7	<0.001
	2	388	12,378	239	148.7	1.6	24.6	<0.001
	3	6	1,124	40	13.5	3.0	16.8	<0.001
	4	147	6,349	127	76.2	1.7	11.1	0.045
Jewelry, Music Instruments & Toys	1	16	1,543	20	4.5	4.5	12.8	0.011
Publishing	1	1	153	14	1.0	14.0	24.0	<0.001
	2	86	7,746	103	50.8	2.0	21.9	<0.001
	3	37	4,151	68	27.2	2.5	19.5	<0.001
Software and Video-games	1	43	3,012	57	22.6	2.5	17.9	<0.001
	2	215	12,799	162	95.9	1.7	16.0	<0.001
Writing, Performing Arts, Visual Arts and Crafts	1	175	10,546	94	37.3	2.5	29.6	<0.001

Nb = number of significant clusters; Size = number of locations that form the cluster; Nz = number of firms in the cluster; Nf = number of firms in the specified sector (cultural and creative industries); ENf = Expected number of firms in the specified sector (cultural and creative industries); T-stat = statistic value; P-value = p-value indicates significant level

Source: own elaboration.

Table 3 refers to clusters identified for 2009, both for CCI's as a whole and at subsector level. Concretely, we have identified 2 clusters for CCI's with, respectively, 248 and 1,345 firms, and 19 clusters at subsector level that distribute in the following way: Advertising (2 clusters), Architecture & Engineering (1), Cinema, Music, TV & Radio (2), Fashion (3), Graphic Arts & Printing (4), Jewellery, Music Instruments & Toys (1), Publishing (3), Software & Video Games (2), and Writing, Performing Arts, Visual Arts & Crafts (1).

Table 4 Cultural & Creative Industries (Clusters-Ellipsoids at 10%) Year 2017

Industry	Nb	Size	Nz	Nf	ENf	Nf/ENf	T-Stat	P_Value
Cultural & Creative Industries	1	302	9,824	1,445	875.9	1.6	140.3	<0.001
	2	154	8,318	925	741.6	1.2	21.8	<0.001
Advertising	1	105	9,833	314	141.4	2.2	90.7	<0.001
	2	99	9,778	255	140.3	1.8	32.1	<0.001
	3	1	35	9	0.5	18.0	17.5	0.00
Architecture & Engineering	1	165	9,589	373	215.8	1.7	50.2	<0.001
Cinema, Music and TV and radio	1	278	9,787	191	68.9	2.8	74.0	<0.001
Fashion	1	80	2,235	108	12.0	9.0	151.3	<0.001
	2	1	104	34	0.6	61.2	107.5	<0.001
	3	7	541	20	2.9	7.0	18.9	<0.001
	4	33	236	10	1.3	8.0	11.8	0.02
Graphic Arts & Printing	1	267	6,998	173	78.6	2.2	40.3	<0.001
	2	158	3,899	117	43.8	2.7	38.4	<0.001
	3	74	2,744	73	30.8	2.4	20.4	<0.001
	4	11	123	11	1.4	7.9	11.5	0.03
Jewelry, Music Instruments & Toys	1	484	9,653	57	27.4	2.1	13.7	0.005
Photography	1	260	6,954	37	12.8	2.9	16.0	0.00
Publishing	1	260	9,642	144	57.6	2.5	45.9	<0.001
	2	1	179	14	1.0	13.1	23.2	<0.001
	3	139	9,148	102	54.7	1.9	17.4	0.00
Research & Development	1	1	207	17	0.5	36.2	45.1	<0.001
Software and Video-games	1	57	2,448	83	27.9	3.0	36.0	<0.001
	2	108	3,916	96	44.7	2.1	20.2	<0.001
	3	52	4,241	95	48.4	2.0	16.0	0.00
Writing, Performing Arts, Visual Arts and Crafts	1	115	5,797	73	23.3	3.1	36.3	<0.001
	2	25	2,379	31	9.6	3.2	15.3	0.00
	3	102	3,734	38	15.0	2.5	12.7	0.01

**Activities related to Heritage have no significant clusters in both years 2009 and 2017

** Photography and Research and Development have significant clusters in 2017 but NOT in 2009

***Firms related to the "Design" have no data in the SABI, i.e. we did not find firms registered under this category

Nb = number of significant clusters; Size = number of locations that form the cluster; Nz = number of firms in the cluster; Nf = number of firms in the specified sector (cultural and creative industries); ENf = Expected number of firms in the specified sector (cultural and creative industries); T-stat = statistic value; P-value = p-value indicates significant level

Source: own elaboration.

Data for 2017 is shown in Table 4. Concretely, the number of clusters for CCI's as a whole remains the same, however the number of firms in each cluster has a erratic behaviour depending the number of clusters identified: concretely, considering one cluster from 248 to 1,445 firms, and considering two clusters from 1,345 to 925. As for the number of clusters at subsector level, it increases and now distributes as follows: Advertising (3 clusters), Architecture & Engineering (1), Cinema, Music, TV & Radio

(1), Fashion (4), Graphic Arts & Printing (4), Jewellery, Music Instruments & Toys (1), Photography (1), Publishing (3), Research & Development (2), Software & Video Games (3), and Writing, Performing Arts, Visual Arts & Crafts (3).

Apart from the number of clusters, what matters is their geographical distribution, as firms' preferences in terms of spatial proximity are shaped by locational attractiveness of each area and, specially, potential agglomeration economies to be generated locally. In this sense, Figures 1 and 2 show the overall distribution of CCI's clusters showing the key role played by the city of Barcelona, a result supported by previous analyses (see, for instance, Coll-Martínez et al., 2019).

Figure 1 Cultural & Creative Industries (All Inclusive) (Ellipsoid Clusters, 2009)

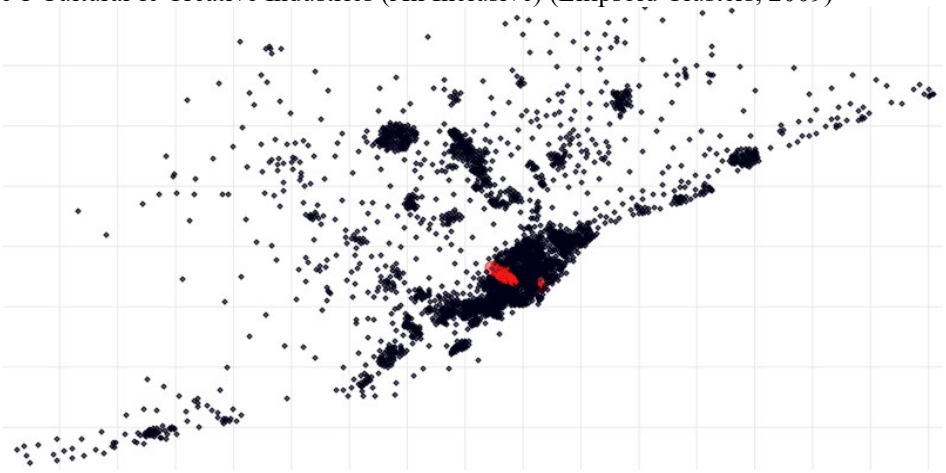
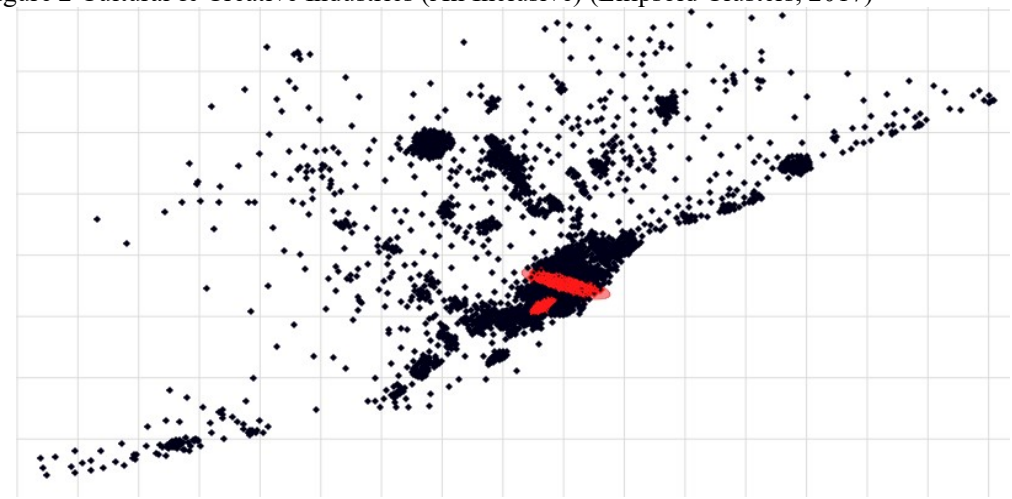


Figure 2 Cultural & Creative Industries (All Inclusive) (Ellipsoid Clusters, 2017)



Source: own elaboration.

Apart from reasonable changes due to firm turnover between 2009 and 2017, figures 1 and 2 demonstrate that clusters' benefits are stronger close to main agglomerated areas

(i.e., in and around Barcelona), as in these places is easier to maximise interactions. Previous results refer to clusters of CCIs as a whole, but in terms of clusters of specific CCIs results are slightly different, as these specialised clusters are driven by local sources of competitiveness arising from given industries.

When referring to industry specific clusters, results for 2009 (see Figure 3) show as well a clear preference for agglomeration at the core of the metropolitan area. Industry clusters include at least one cluster in Barcelona city and the additional ones are at different municipalities of the metropolitan area, depending on their industry specialization. In general terms, subsectors linked to high-tech / cultural / service oriented industries tend to cluster mainly in Barcelona, whilst those closely connected with manufacturing activities show a more dispersed pattern. An exception of that close connection to Barcelona city is that of Fashion industry cluster, for which the main area is located outside Barcelona city centre, but this CCI cluster is mainly driven by Fashion firms and not by a wide agglomeration of CCI's firms.

[INSERT FIGURE 3 AROUND HERE]

Results for 2017 are quite similar to those of 2009, which is reasonable taking into account that cluster formation is a medium/long term process. Nevertheless, there is one interesting difference that arises when comparing both periods. Concretely, it seems that clusters located at Barcelona city center have strengthened over that period. This process can be understood in terms of urban resilience during economic downturn (Martin and Sunley, 2015), as firms located in dense urban areas are "protected" by a complex network of firms' interactions that help them to continue operating in markets. An additional explanation is provided by role of public policies supporting cluster's formation in areas like 22@ district in Barcelona (Viladecans-Marsal and Arauzo-Carod, 2012), as high-tech forms from several CCIs have tried to benefit from advantages existing in these areas. It is also true that competition is tough in these areas and that increased competition makes survival more difficult, but our empirical results suggest that net results are positive.

[INSERT FIGURE 4 AROUND HERE]

Figures 3 and 4 show cluster's at subsector level. It is worth noting that number of industries differs across these figures as not all of them have been identified for the 2 years considered. In general terms, we may distinguish clusters between those located at core of the metropolitan area of Barcelona and at its periphery. The formers correspond to industries like Advertising, Cinema, Music, TV & Radio, Heritage, Photography, Publishing and Writing, Performing Arts, Visual Arts & Craft. The later corresponds mainly to Architecture & Engineering, Fashion, Graphic Arts & Printing and Jewellery, Music Instruments & Toys.

There is also evidence of industries that seem to follow both strategies, as Software and Video-games, distributed in several clusters in Sant Cugat del Vallès, and at 22@ district and Diagonal avenue in Barcelona. Nevertheless, we guess that this result is partially biased by the industry aggregation level used in this paper (i.e., as software and video-games firms are considered together), as there is clear empirical evidence showing the existence of concentration of video-games firms at 22@ (Méndez-Ortega and Arauzo-Carod, 2019).

It is also interesting to notice that a high-tech industry like Research & Development and Software shows some sort of suburbanization (between 2009 and 2017) towards Vallès Occidental county. In that area (specially in and around Sant Cugat del Vallès and the Autonomous University of Barcelona) several high-tech firms have located in recent years, helping to upgrade the traditional manufacturing base existent before.

A general approach to previous results indicates that due to asymmetries space matters, and that firms look for these asymmetries when deciding the location of their venues. That is why several specialised clusters emerge and survive across years, trying to take advantage of existing business and social ties at different locations, as well as availability of specialised labour and infrastructures, public resources and intermediate and final markets.

5. Conclusions

This paper has tried to shed some light on clustering of CCIs. Although clustering patterns have been extensively analysed for economic activity as a whole and for specific industries, empirical evidence regarding CCIs is still scarce. In this sense, there are several analyses focusing on clusterisation patterns of these industries, but mainly from a qualitative perspective, without providing strong empirical evidence supporting that behaviour.

There are several policy implications arising from this paper. The first one refers to the natural tendency of firms to cluster, which is also true for CCIs. This fact suggests to provide location conditions that may facilitate cluster formation of similar industries, assuming that if firms look for similar neighbours is because they benefit from this geographic proximity. The second one refers to urban resilience identified when comparing cluster maps for 2009 and 2017. In this sense, if dense urban areas (e.g., Barcelona) provide additional resilience, then public administrations should take this urban effect into account when planning land zoning for specific economic activities.

As for future extensions of this research, it is clear that after identifying where and when CCIs cluster it is needed to analyse whether that pattern has any effect in terms of firms' efficiency and / or turnover. In this sense, a future extension of this paper will concentrate on the effects of clusters in terms of locational determinants of firms belonging to the same CCIs, in order to check if cluster benefits are perceived as strong locational determinants by entering firms.

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