UNIVERSITAT ROVIRA I VIRGILI

LOCATION OF SOFTWARE AND VIDEO GAME INDUSTRY IN METROPOLITAN AREAS

Carles Méndez Ortega

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Location of Software and Video Game Industry in Metropolitan Areas

PH.D. DISSERTATION

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I STATE that the present study, entitled *Location of Software and Video Game Industry in Metropolitan Areas*, presented by Carles Méndez-Ortega for the award of the degree of Doctor, has been carried out under my supervision at the Department of Economics of this university, and that it fulfils all the requirements to receive the European/International Doctorate Distinction.

Reus, June 21st, 2019

Doctoral Thesis Supervisor

Josep-Maria Arauzo-Carod

"Everything is related to everything else, but near things are more related than distant things."

-Waldo Tobler

"We are stuck with technology when what we really want is just stuff that works."

-Douglas Adams

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Abstract

This thesis identifies and analyses the factors that determine the location of Software and Video Game firms (SVE) in metropolitan areas, by analysing the location and agglomeration of these firms with other creative firms and its pattern at urban level. This thesis contributes to the literature on high-tech industries by analysing their location patterns at the urban level using a wide range of methodological tools (spatial econometrics, distance-based methods and Geographical Information Systems, among others). The empirical application focuses mainly on Barcelona and its metropolitan area, as well as on the metropolitan areas of Lyon and Hamburg, for the period 2011-2015. The main findings show that small, new firms belonging to this industry tend to be more concentrated than big, old ones. In terms of collocation, SVE firms tend to collocate with creative industries, and this collocation is the same across different metropolitan areas. Moreover, this thesis has confirmed the location determinants of this industry and, although these determinants are not so different from the determinants of these creative and non-creative firms, SVE firms tend to choose locations with a high diversity of cultural and creative activity, and good high-tech amenities. Finally, this thesis highlights the predominant role of urban cores in metropolitan areas and important specificities in terms of the core-periphery distribution of SVE firms and the role that urban renewal projects (e.g., 22@ district) play in the location pattern of these firms. These results raise some interesting issues for policy makers, since the promotion and attraction of creative activities, in conjunction with the factors mentioned above, will contribute to the location of SVE activities, which are fundamental to economic growth and will boost the economic development of cities.

Keywords: Software and Video Game industry, agglomeration, location patterns.

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Chapter 1

Introduction

Today, activities such as sending a message, watching the news, buying books, electronics or food, consulting an encyclopaedia, booking a hotel, making payments, and even socializing can be done with a small device (e.g. mobile phone). Just a few decades ago this was unthinkable. In the last 50 years, society has undergone a radical change as a result of the technological revolution that has boosted technological innovation in many areas.

While this innovation is largely tangible, most of the process was mainly cognitive, since the technological revolution has involved transformations in the way in which knowledge is acquired (i.e. the way in which people interact each other) (Parayil, 1991). The technologies that have led to the development of the applications we are using and the environments in which we are moving and socializing nowadays are the direct result of computer science and the Software industry.

This thesis will focus on the Software and Video Game industry (hereafter SVE), a creative industry within the Information and Communications Technology industry (ICT).

According to UNCTAD (2010), creative industries are a set of knowledge-based activities, focused on but not related to arts, which use creativity as the main input for providing goods or services with creative content and economic value. They are now a new dynamic sector in world trade.[1] They engage in such activities as R&D, advertising, cinema, fashion, graphic arts or Software. The fact that this definition is so broad has given rise to a debate about which activities are actually part of the creative industries (Lazzeretti and Capone, 2015; Sánchez-Serra, 2016). This thesis relies on UNCTAD's definition of creative industries, since it is widely accepted by researchers and institutions (Boix and Lazzeretti, 2012; Coll-Martínez and Arauzo-Carod, 2017).[2]

Interest in the SVE industry is growing because it is having a considerable impact on a wide range of sectors in the current world economy. In 2013, the total revenue of Software companies worldwide was over 400 billion dollars, a 4.8 percent increase on 2012 when the total revenue was 388 billion dollars (Gartner Inc., 2014). Indeed, in 2014, the total contribution of this industry to the European Union (EU28) economy in terms of GDP was more than 900 billion euros (7.9% of the EU28 GDP) and it generated more than 11.6 million jobs (5.3% of the EU28 jobs), of which 3.1 million were direct. Wages are considerably higher than in other industries (e.g. the EU average wage in the Software industry is 34% higher than the EU average wage and 80% higher than the wage in the services sector). This is because it is a highly qualified industry with highly skilled workers (BSA and The Economist Intelligence Unit, 2016). The total contribution of this industry to the GDP of Spain is more than 35,800 million euros (3.4% of the Spanish GDP) and more than 624,000 jobs are SVE-industry

[1] UNCTAD is the part of the United Nations Secretariat and deals with trade, investment, and development issues.
[2] Defining and exploring a list of creative industries is a complex task that is beyond the scope of this thesis.

related (219,000 direct and 400,000 indirect jobs). In Spain, this sector has 360,000 employees (whose average salary is over 30,000 euros per year) and adds 30 billion euros of gross output to the Spanish economy (INE, 2016). However, as has been mentioned above, the impact of the SVE industry is much greater than economic indicators suggest, since its technology is present in almost all economic sectors.

Despite being an industry that is largely located in urban areas, most empirical studies on the location determinants of SVE and high-tech firms in general have been carried out at country and/or regional level (Goetz and Rupasingha, 2002; Li et al., 2016) or even at municipality level (Hackler, 2003) and have not analysed the location of these firms at intra-urban level. Moreover, the relationship of SVE firms with other creative industries at urban level has not been explored in the literature (Coll-Martínez et al., 2019, compared the urban creative industries in the metropolitan area of Barcelona, but did not go into the SVE industry).

For this reason, the main aim of this thesis is to analyse these location determinants on the urban scale and find new empirical evidence on the intra-urban location of Software and Video Game firms by *i)* analysing the location patterns of SVE firms in metropolitan areas, and the agglomeration patterns of these firms with other creative industries, *ii)* investigating the role urban renewal projects have played and are playing in the intra-urban location of SVE firms and finally*, iii)* determining why SVE firms choose certain areas in the city (i.e. its entry determinants at city level). Therefore, this thesis makes a wide-ranging contribution to the literature and is important to policy makers, since *i)* it reveals the patterns and location determinants that SVE firms follow at the urban level and establishes which strategies they pursue to attract this type of industry and *ii)* uses a wide variety of methodologies (Spatial Count Data Models, distance-based functions and Geographical Information Systems (GIS) due to the availability of micro-geographic data).

The empirical application of this thesis use data from Barcelona, Lyon and Hamburg and their metropolitan areas, although the main focus is Barcelona, which is located in Catalonia, a Mediterranean region with an industrial tradition, but nowadays with a strong business mind-set and a location that is strategic for market access. Catalonia is regarded as the most attractive region in Spain for foreign investors, concentrating more than 87% of FDI projects, 97% of capital investment and 95% of the jobs created within the Video Game sector in Spain between 2013 and 2018 (Catalonia Trade & Investment, 2018).

Confidence in public and private institutions, a pool of local and international talent, a powerful technological industry and the dynamic and innovative ecosystem of high-tech and creative activities make Barcelona an optimal city for attracting talent and foreign investment (fDi Intelligence, 2018). In particular, Barcelona was the leading European city in terms of innovation (2014), the first hub in Southern Europe in terms of start-ups (2017) and the fourth city in the world in terms of creativity (2016), only behind London, New York and Berlin (Catalonia Trade & Investment, 2018). Some other key facts highlight the potential of the city for Software and Video Game industry: for example, the Barcelona Games World, a yearly worldwide event held in Madrid until 2015 then moved to Barcelona, and the increasing number of university degree courses available at local universities, focusing on Software, Video Game design and Video Game management.[3]

Although Barcelona has a long tradition of manufacturing activities, these started to decline in the early 1970s, leaving enormous areas of free land available for further urban growth.[4] In order to enhance the potentiality of Barcelona, in 2000 the Barcelona City Council started an urban renewal project in the Poblenou area, which aimed to transform this area from a mature textile manufacturing cluster into a high-tech cluster known as 22@. The policy has been a success and has attracted – and is still attracting – many high-tech firms and knowledge-based activities (Viladecans-Marsal and Arauzo-Carod, 2012). These factors, in conjunction with the capacity of Barcelona to generate creativity and entrepreneurship, explain why this city and its metropolitan area are an appropriate case for analysing the location and collocation strategies that SVE firms adopt at urban level.

The remainder of this thesis is structured as follows. The second chapter provides an intra-metropolitan analysis of the SVE industry for the metropolitan area of Barcelona using microgeographic data. The third chapter extends this analysis to other metropolitan areas (i.e., Barcelona, Lyon and Hamburg), in order to analyse whether the specificities of metropolitan areas generate differences in location strategies for the SVE industry. The fourth chapter adopts an intra-urban approach (i.e., the city of Barcelona) to analyse the location

[3] The University of Barcelona (UB), the Politècnica de Catalunya University (UPC) and the Pompeu Fabra University (UPF) offer bachelor's and master's degrees on Software and Video Game.
[4] At the beginning of the 1970s, most factories started to move away from the city center. This was a trend followed by the main cities in Europe (e.g. Manchester, Hamburg, Lyon, among many others).

determinants of entering SVE firms. Finally, the fifth chapter discusses the main conclusions of the thesis and further research on this topic.

1.1 Thesis contents

The second chapter of this thesis, which has been published in the *Journal of Urban Technology* (Méndez-Ortega and Arauzo-Carod, 2019b), analyses the location patterns of SVE firms in the metropolitan area of Barcelona using microgeographic data. With techniques such as the Nearest Neighbour Index (NNI), Moran Index (Moran's I), the Local Indicator of Spatial Association (LISA) and Marcon functions (M-functions), it analyses the reasons why SVE firms choose certain areas of Barcelona and its metropolitan area. Moreover, results suggest that although both types of firm (Software and Video Game) are concentrated in and around the metropolitan area, the concentration of Video Game firms is noticeable in the city centre of Barcelona and particularly around two sub-centres in the central business district of Barcelona (both sides of the Avinguda Diagonal) and the 22@ district. Also, clustering appears to be a competitive strategy for younger and smaller firms that need spatial proximity with similar firms in the same industry in order to benefit from positive agglomeration externalities. This is a well-established effect, which is also known as liability of newness and liability of smallness (Agarwal et al., 2002). Finally, it is also shown that, whereas there is an agglomeration effect between SVE firms and other creative firms (i.e. advertising and related services, video and film industries) there tends to be a dispersion effect with graphic arts. Therefore, this chapter contributes to the literature by shedding light on the location of this industry and its relationship with other creative industries at intra-urban level.

Having said this, it seems that SVE firms have a particular pattern in the city of Barcelona and its metropolitan area, just as it also seems that the 22@ district plays a crucial role in attracting SVE firms, which generates a polycentric pattern in Barcelona. So, it would be interesting to analyze whether this location pattern and strategy differs from that of other similar metropolitan areas which have developed urban renewal projects similar to Barcelona's.

In this context, the third chapter of this thesis, which has been published in *The Annals of Regional Science* (Méndez-Ortega and Arauzo-Carod, 2019a), analyses common location patterns of SVE firms in the metropolitan area of Barcelona, Lyon and Hamburg. These three cities share some features in terms of size, manufacturing tradition and, specially, economic strategies, as they have managed to promote high-tech neighbourhoods through ambitious urban renewal policies. The use of techniques such as NNI, Kernel densities, Kd-functions and the Entropy Index reveals the patterns SVE firms are following in each metropolitan area and the role of their urban renewal projects. Although in three cities SVEs firms locate in core areas, the intensity of their centralization varies, as firms in Hamburg are strongly agglomerated in central areas, but this phenomenon is not so pronounced in Barcelona or, particularly, Lyon. Nevertheless, there is a common pattern for all three areas, as SVEs firms co-locate close to firms belonging to other creative industries such as radio and TV, advertising and video and film industries. Moreover, the results provide evidence that SVE firms tend to locate in places in which values such as tolerance, diversity and skilled human capital act as drivers of high technology entrepreneurship (Qian, 2013), and creativity and multicultural environment give these firms an important stimulus in terms of innovation and growth (Florida and Gates, 2003). So, this chapter contributes to the literature by providing clear and robust empirical evidence on how and where the industry agglomerates, and suggesting policies that are useful for cities that have already started high-tech urban renewal projects or may start these projects as a tool for promoting local growth.

Once the location and collocation patterns of existing SVE firms at urban level have been observed and the role of each urban renewal project in the distribution of these firms within the city has been reported, it is of particular interest to see which pattern new firms will follow (i.e. which areas of the city a new SVE firm will choose).

In this regard, the fourth chapter of this thesis studies the reasons behind the intra-urban location decisions of Software and Video Game firms in metropolitan areas. To carry out this analysis, a set of covariates that capture neighbourhood characteristics (localization and agglomeration economies, high-tech amenities, diversity, human capital and crime) are used to determine the SVE firm entries at the neighbourhood level in the city of Barcelona between 2011 and 2013. The econometric methods used to measure the impact of these variables on SVE firms' entries were both non-spatial (Count Data Models) and spatial (the Spatial Autoregressive Poisson Model by Lambert et al., [2010] and the Spatial Lag Model). The results show that at city level, SVE firms tend to choose locations with high-tech amenities (e.g. 22@ district in Barcelona) as other studies have suggested at a more aggregated level (municipality/regional level)

(Acosta et al., 2011; Hackler, 2003; Kinne and Resch, 2017), and a wide range of creative firms and social amenities. They also show the importance of agglomeration economies: SVE firms choose locations with a large number of established SVE firms, which shows the importance of spatial spillovers for this type of firm. This chapter contributes to the literature with a study of the location determinants of the SVE industry at the urban level, which focuses on factors that have either not been considered or not been analysed together at this level.

Finally, the fifth chapter of this thesis presents the main conclusions, the corresponding implications for policy and further research directions.

Chapter 2

Locating Software and Video Game Firms: Using Microgeographic Data to Study Barcelona[5]

2.1 Introduction

The Software industry has transformed the way in which organizations, firms and workers are coordinated and behave, and its impact on the global economy can be measured by the increased rate of technical progress and continuous innovations.

This industry, which has gone from a position of obscurity to indispensability in less than fifty years, emerged in the mid-1970s and in the 1980s and 1990s, with the development of the Personal Computer and the establishment of the World Wide Web, that led this sector to expand exponentially. Today, the Software industry is of major importance for the contemporary economy, accounting for a significant proportion of the information and communication technology sector (ICT), which contributes 5.4% to global gross domestic product (Dutta and Mia, 2010). In specific terms, 1.87 million people in the United States work in this sector, earning an average yearly salary of one hundred thousand dollars (more than twice the national average) and

[5] This chapter is co-authored with J.M. Arauzo-Carod. It has already been published in the *Journal of Urban Technology*.

generating more than 412 billion dollars of gross output for the US economy (OECD, 2010). In Spain, this sector provides 360 thousand employees (whose average salary is over 30 thousand euros per year) and adds 30 billion euros of gross output to the Spanish economy (INE, 2013). This industry includes Software management, programming, editing electronics, mobile Software (or apps) and the Video Game industry.In this chapter we will focus on the Software and Video Game industry (hereafter SVE), a specific creative industry within the Information and Communications Technology industry (ICT) that falls halfway between the ICT industry and creative industries, and shares some characteristics with both (the ICT's exponential growth, technical processes and business features and the creative industries' creative components). [6] Inside SVE, we focus on Video Game industry. The Video Game industry includes software created for entertainment purposes and electronic devices (mobile phones, Personal Computers, arcade machines and Video Game Consoles, among others) that runs the game. Video games emerged in the United States in the early 1960s with the first computer game "Spacewars". This game was inspired by science fiction novels and featured two spaceships shooting beams to destroy each other. The first viable business in Video games was developed by Nolan Bushnell, the founder of Atari (Aoyama and Izushi, 2003). Atari initially created and later fuelled the Video Game industry, focusing at the beginning on bigger markets, such as those in Japan (with firms as Nintendo and Sega) and the United States (with Atari and Microsoft).

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[6] Creative Industries are a group of industries linked to culture, creative and high-tech activities that, among others, include activities such Publishing, Audio-visual, Arts, Advertising, R&D and Software.

Since the 1970s, the Video Game industry has developed in tandem with the digital revolution, and the industry has experienced exponential growth. The industry's global spending amounted to 70.8 billion dollars in 2014, with a forecast of 89 billion dollars for 2018, or an annual mean global growth rate of 6.2% (PwC, 2018). In Spain, according to PwC (2017) this industry had an income of about 1078 million dollars in 2013, with a forecast of 1238 million dollars for 2017 (an annual growth rate of 3.3%) and is strongly concentrated in Catalonia (a region located in north-eastern Spain) and, concretely, in its capital, Barcelona. Catalan firms have around 1,600 workers and in 2015 developed about 150 games (40% of which were for mobiles and 30% for online platforms).[7]

The SVE firm's location preferences are mainly inside big metropolitan areas, and specifically in the core of them, where they can easily find skilled young professionals who are crucial to the success of these activities. There is empirical evidence for the huge importance of skilled labour for this industry and specifically, workers with outstanding capabilities in computer skills, such as computer programming and Software engineering (Autor et al., 2003). The availability of this skilled labour is a basic input for high-tech firms (which are overrepresented in large urban areas) and it even has a positive effect on urban city growth (Berger and Frey, 2016).

When dealing with location and agglomeration issues of the SVE firms it is important to take into account three dimensions closely related. The first one is about the positive spillover effects at city level (Berger and

[7] Data from the *Institut Català de les Empreses Culturals*: "Empreses de videojocs a Catalunya 2015" except the data concerning the number of employees, which is from our database.

Frey, 2016; Currid, 2006 and Glaeser, 1998). The second one is about the agglomeration processes of creative industries, a phenomenon that has been analysed both at country (Boix et al., 2015; Cruz and Teixeira, 2014; Lazzeretti et al., 2012) and city (Coll-Martínez et al., 2019; which shows for the case of Barcelona that Creative firms are located mainly in urban spaces and are more agglomerated than non-creative firms) level. And the third one is about the agglomeration processes of Software (Ó Riain, 1997, and Parthasarathy, 2004) and Video Game (Murphy et al., 2015, and Tschang and Vang, 2008) firms, which has also been approached at country and city level. In this sense, this chapter fits into previous literature as it deals with location patterns of an industry that tends to agglomerate at the core of big cities in view of the positive externalities that arise from these areas thanks to proximity and interactions among firms.

Concretely, we aim to analyse a case study of SVE firms for the metropolitan area of Barcelona (hereinafter the MAB), which has increasingly attracted this type of activity in recent years, due to some huge advantages, as partially illustrated by the increasing number of university degree courses available at local universities,[8] focusing on Video Game design and on Video Game management.[9] Some key facts highlight the potentiality of this city for this industry, such as *Barcelona Games World*, an annual worldwide event held in Madrid until 2015

[8] Universities play an important role on creation of High Tech firms, but it is not the only key factor for the success of these industries, also the local environment or the innovative milieu (Mayer, 2007).
[9] The Universitat de Barcelona (UB), the Universitat Politècnica de Catalunya (UPC) and the Universitat Pompeu Fabra (UPF) offer Bachelor's and Master's degrees focusing on Video games.

which subsequently later moved to Barcelona. Although Barcelona has a long tradition of manufacturing activities, these had rapidly disappeared since the late 1970s, when most factories started to move away from the city centre, leaving enormous areas of free land available for further urban growth. Although some of these areas were transformed into residential areas, there are some interesting experiences of urban renewal projects that aimed to transform them into high-tech districts. The most famous of these is in Poblenou, a district quite close to the city centre, which in 2000 was the subject of a renewal plan by Barcelona City Council which aimed to transform this area from a mature textile manufacturing cluster into a high-tech cluster known as 22@. That experience has been a successful policy that has attracted many high-tech firms and knowledge based activities (Viladecans-Marsal and Arauzo-Carod, 2012). In spite of the success of the 22@ experience, not all new high-tech related activities have decided to locate there, as many other core areas have also attracted these new firms.

In terms of the contribution of this chapter, we argue that there is wide empirical evidence showing that at city level (i.e., at short distances) there are positive spillover effects that increase productivity of firms located in dense agglomerations, that these effects differ at industry level as not all industries share the same agglomeration patterns, that creative industries have a stronger tendency to agglomerate (and, potentially, to benefit from these effects), and that among creative industries, SVE firms have even additional motivations to cluster, given that knowledge spillovers may be higher among firms from this industry. As a consequence, we suggest that clusterisation process in big urban areas and, concretely, in specific central areas of these cities, may be explained in terms of positive externalities arising from physical proximity thanks to knowledge spillovers, a key input in a highly innovative industry where labour mobility among firms is quite important. Concretely, these positive effects arising from physical proximity will be the hypothesis to be tested in this chapter (see next section). To that end, we have used spatial oriented techniques including the Nearest Neighbour Index (NNI), M-functions and spatial autocorrelation indicators (global and local). Our preliminary results indicate that Video Game firms tend to cluster around some subcentres inside the MAB, whilst Software firms are less concentrated. The next step in our research will be to attempt to determine what explains these location patterns and therefore drives the location determinants of these firms.

The rest of the chapter is organized as follows. Section 2 reviews the theoretical and empirical literature about firms' location determinants, focusing on the Creative industries and specifically on the SVE firms. Section 3 describes the data and methodology. Section 4 introduces some descriptive statistics and discusses results, and finally, Section 5 presents the main conclusions.

2.2 Literature Review

This chapter falls between two closely linked strands of economic literature, namely industrial location determinants and agglomeration economies. The first field, about industrial location determinants, has been a recurring topic in economics since the seminal contribution by Alfred Marshall (1890) on industrial districts and the study by Edgar and Hoover (1936), among other authors. The literature exploring the location decisions of new firms has grown considerably in recent years, with wider methodologies, spatial aggregation levels and industries being analysed. That success is partially explained in terms of the potential utility of these contributions when designing public policies aiming to attract new firms.[10] The second field, about agglomeration economies, shows that economic activity has a strong tendency to agglomerate, regardless of the industries, geographical areas or institutional settings concerned, although these characteristics modulate the degree of agglomeration effectively achieved. If we consider both strands together, we may conclude that *i)* firms have a clear tendency to agglomerate around other firms and *ii)* firms share specific location patterns with similar firms.

Nevertheless, our main aim is to analyse spatial distribution of all firms (both entering and incumbent ones) no matter the moment in which they have chosen their current location. In this sense, we will concentrate our analysis on agglomeration economies, as they are hypothesized to be the main driving forces behind location patterns.

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[10] An extensive review of this literature can be found in Arauzo-Carod et al., (2010).

As the contributions to the literature on agglomeration economics are quite varied and address the location of economic activities in quite different ways, there have been various attempts to organize and structure them. Albert et al. (2012, p.109) consider that "this literature has been influenced by two very different traditions, economic geography and spatial statistics, and therefore has followed two different paths". The first traditions (economic geography), dealt with polygons (i.e., administrative areas) and typically used measures as the Gini or Herfindhal indices and did not take space into account in their analyses and may have consequently contained important levels bias. Later, some authors tried to overcome the previous shortcomings by controlling for space, agglomeration and co-agglomeration, for example Ellison and Glaeser (1997), Maurel and Sédillot (1999) and Rosenthal and Strange (2003), among others. Later, Duranton and Overman (2005) treated space as continuous, in a strategy that overcame the previous limitations caused by MAUP, such as potential comparisons across different spatial aggregation levels. The second traditions (spatial statistics) dealt with points (i.e., firms), considering only the closest points (e.g. the Nearest Neighbour Index) or taking into account all neighbour points (e.g. K functions). K functions were initially developed by Ripley (1976) and later improved by Marcon and Puech (2010). With the introduction of these tools, numerous papers were published analysing spatial patterns in particular industries, such as food stores in Italy, analysed by Arbia et al. (2015), media industries in London by Pratt (2011), high tech industries in Milan by Espa et al. (2013), manufacturing firms in Europe by Brülhart (2001), or in a completely different area, tree location in North American forests by Li and Zhang (2007).

By focusing on agglomeration processes in cities, and as in this chapter we analyse the agglomeration of a particular creative industry, it is important to mention why creative industries agglomerate. There are two main forces producing positive externalities by geographical concentration: localization and urbanization economies (Lorenzen and Frederiksen, 2008). While the first take advantage of the co-agglomeration due to the specialization, the second take advantage of the industry diversity (more common in large cities). As we are analysing an industry mainly located in urban areas, we focus on urbanization economies. In this sense, factors as labour heterogeneity, abandoned facilities of declining industries (e.g., as at 22@ district) and a large diversity of firms having unrelated knowledge bases may produce positive spillover effects that even offset high costs associated to urban congestion (Lorenzen and Frederiksen, 2008).

A relevant topic to be discussed is the role of proximity on agglomeration, an issue that has become relevant since the work of Becattini (1991), where the benefits of proximity in terms of innovation and development through Marshallian industrial districts are shown. Concretely, high population density and very skilled human capital existent in cities create an environment where ideas flow easily facilitating the generation of positive spillovers (Florida, 2002; Presutti et al., 2019). However, some scholars have suggested that proximity does not clearly benefit high-tech industries, since their knowledge can be better codified than that of other type of industries (Breschi et al., 2003 and Shefer and Frenkel, 1998) and, as a consequence, geographical proximity is less relevant for knowledge transfer.

Apart from the aforementioned framework for the location of economic activity and agglomeration economies, this chapter specifically covers the Video Game industry, an area for which analyses are still relatively scarce, both because it is a young industry and because its borders are blurred between the Software industry and creative industries (Lorenzen and Frederiksen, 2008). It is for this reason that we present main findings related to the location determinants of all these areas: Software industry, Creative industries and the Video Game industry.

First, for location analyses of SVE industry, there is extensive literature related to location determinants across countries (e.g., Parthasarathy, 2004, for India; Weterings and Boschma, 2009, for the Netherlands and Ó Riain, 1997, for Ireland), at city level (e.g., Isaksen, 2004) and at a microgeographic country level (e.g., Kinne and Resch, 2018) that tries to identify the type of economic and social environment preferred by firms from this industry. It is a well-established fact that these firms benefit from networking and spillover effects, as well as information flows due to R&D cooperation (Cassiman and Veugelers, 2002). Additionally, the empirical evidence shows that information plays a significant role in generating a positive effect over these firms' productivity when they are located in the same area (Arzaghi and Henderson, 2008) and that physical proximity between these firms can be essential for some exchanges of knowledge, enhancing innovation processes (Morgan, 2004).

Second, a large body of literature has explored the clustering of creative activities as Publishing (Heebels and Boschma, 2011), Music (Hracs, 2015), Fashion firms (Wenting, 2008), Film and TV industry (Foster et al., 2015) or Co-working spaces, essential for creative development activities (Mariotti et al., 2017), and their positive influence on the city's growth (e.g., Berger and Frey, 2016 and Currid, 2006). As with Software industry, firms' clustering is widely acknowledged at various spatial levels, including continental level (e.g., Boix et al., 2015, for the case of Europe), national level (e.g., Cruz and Teixeira, 2014, for the case of Portugal, Rehák and Chovanec, 2012, for the case of Slovakia and Lazzeretti et al., 2012, for the cases of Spain and Italy), and at city level (e.g., Slach et al., 2015, for Ostrava; and Inkinen and Kaakinen, 2016, for Helsinki Metropolitan Area). All these studies show that creative firms are highly clustered, and mostly located in metropolitan areas around medium-sized and large cities and cross-border areas with an important concentration of creative and knowledge-based activities. Generally speaking, the places that attract these activities are areas with high levels of tolerance, open-mindedness and with a large skilled population.

Third, specific analyses for Video Game industry are quite scarce, partly because these activities have been traditionally considered together with other computer-related activities such as Software design, and also because of their newness as specific economic activities. Analyses covering Video Game industry are therefore quite varied and not easy to categorize together. For instance, while authors like Johns (2006) focus on the importance of the networks in this industry in order to demonstrate the utility of Global Production Network approaches and the uneven impact on the globalization processes, others try to explain intraurban determinants of Computer Games industry alongside other types of creative firms (e.g., Murphy et al., 2015, for the case of Dublin) or adopt a broader geographical approach in which clusters of different sizes are considered (e.g., Darchen, 2015, for Australia; De Vaan et al., 2013, at global level; Santos et al., 2016, for Portugal, and Tschang and Vang, 2008, for the U.S.).

In order to shed some light over location patterns of SVE firms, the main hypothesis tested in this chapter is the following: "As SVE firms benefit from knowledge spillovers and from proximity to firms from the same industry, they will try to maximize these interactions by locating close together at city centre".

2.3 Data and methodology

2.3.1 Data

The data used in this chapter comes from the *Àrea de Cultura Digital* (*Institut Català de les Empreses Culturals*) and SABI (*Sistema de Análisis de Balances Ibéricos*) and corresponds to firm level data in 2015. The former one is a Government of Catalonia public institution responsible for digital media activities including Video Game, books and music, and the latter compiles data on firms using the Mercantile Register. The data obtained for SVE firms is from the SABI Database[11], while the Video

[11] The SABI database contains a long list of variables, including year of constitution, balance sheets, income, expenditure accounts, number of employees, industry, sales, assets, and georeferenced location (X-Y coordinates). The data is collected by SABI

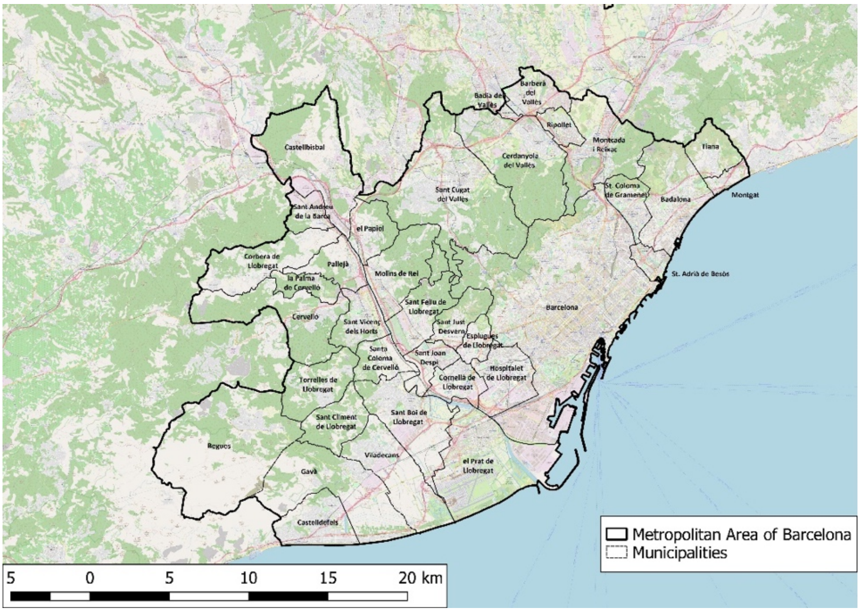
Game firms data were obtained from the *Àrea de Cultura Digital*, which provides an extensive list of Video Game firms obtained from the institution's day-to-day interaction with firms working in this industry. We have matched the two sources, as the SABI data was used to complete the database from the *Àrea de Cultura Digital* (i.e. number of employees, sales and assets, among other characteristics) and we contacted firms directly if the firms listed in the *Àrea de Cultura Digital* were not compiled by the SABI. Our final dataset contains 104 Video Game firms located in Catalonia (25.15% of the Spanish total in 2015)[12], although some of them (17) do not have enough data to be georeferenced.[13]

As mentioned in the introduction, we focus on the MAB, located in Catalonia, north-eastern Spain. The MAB (see Figure 2.1) covers an area of 636 km^2, has around 3.2 million inhabitants and includes 36 municipalities.

from the Mercantile Register, where all limited liability companies and corporations are obliged by law to deposit their balance sheets.

12 Data provided by the Government of Catalonia.
13 Concretely, 2 Video game firms do not report any headquarter and 15 have missing locational data.

Figure 2.1 Metropolitan Area of Barcelona (MAB)



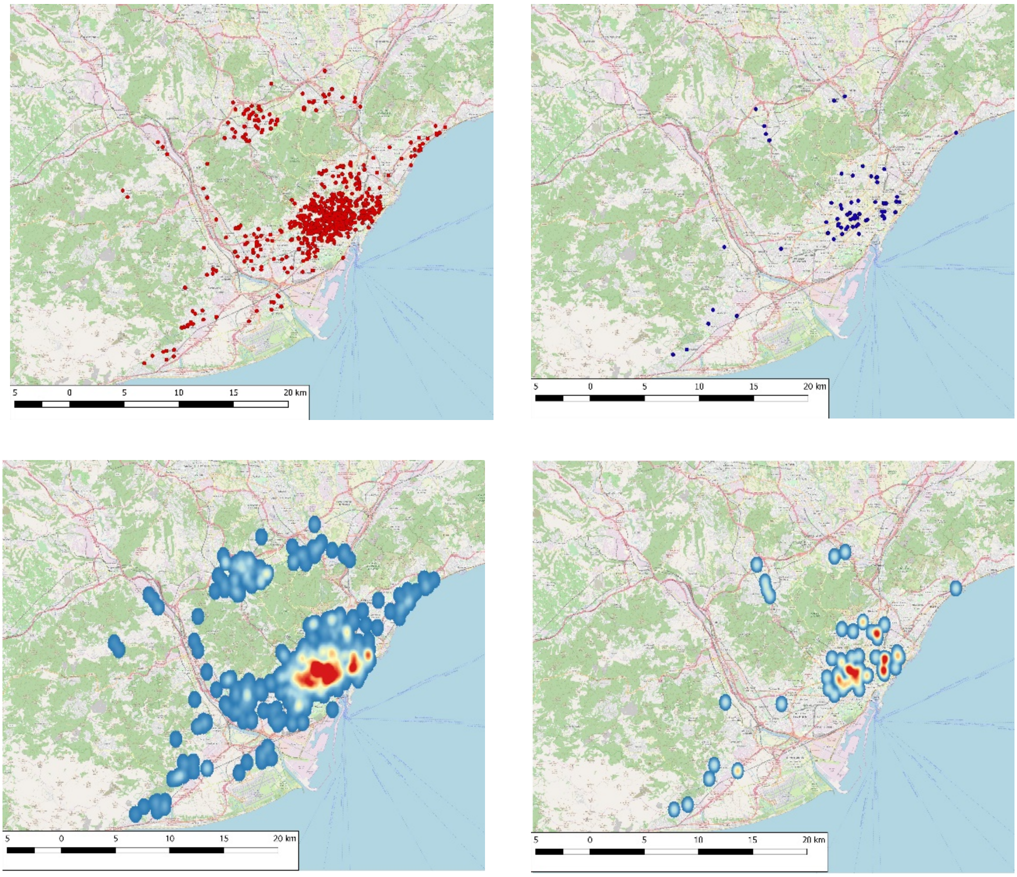
Source: Own Elaboration, map source from http://www.openstreetmap.org/

The main reason to focus on the MAB is the large number of firms located in and around Barcelona. In specific terms, 74 of the 104 Catalan Video Game firms are located in the MAB (54 of them in Barcelona), which accounts for around 71% of firms in the industry. The MAB also attracts a large number of SVE firms: 858 SVE firms including Video Game firms (see Figure 2.2).

Although Barcelona is clearly the economic and institutional hub of the MAB, there are also some spatial inequalities inside the city which need to be controlled. For this reason, we will also divide the city into 10 districts and 73 neighbourhoods. Additionally, using districts will allow us to compare them to municipalities in the MAB other than Barcelona, as they are of a similar size. If we focus on the 10 districts, it is apparent that economic and residential activities are unequally distributed across them.

Figure 2.2 Point and heat map from the SVE and Video Game Industry firms in the MAB

SVE firms **Video Game firms**



Source: SABI, *Institut Català de les Empreses Culturals* and own elaboration.

In order to identify industries to be used, we followed the classification by Boix and Lazzeretti (2012) which summarizes several classifications of creative industries (see Table 2.1).

Table 2.1 Firms of Creative industries in the MAB

Industry	**Acronym**	**N**	**Share**
Advertising and related services	ADV	1,218	15.59
Architecture and Engineering	AE	1,587	20.31
Art and Antiques Trade	ART	47	0.60
Crafts	CR	49	0.63
Publishing	ED	538	6.89
Fashion	FA	380	4.86
Graphic Arts	GA	927	11.87
Heritage, Cultural sites and Recreational Services	HE	691	8.85
Creative Research and Development	IDC	148	1.89
Jewellery, musical instruments, toys and games	JEW	105	1.34
Music and music studies	MU	74	0.95
Performing Arts	PA	264	3.38
Photography	PHO	161	2.06
Radio and TV	RTV	66	0.84
Software, Video Game and Editing Electronics	SVE	858*	10.98
Specialised services design	SSD	272	3.48
Video and film industries	VFI	427	5.47
Total number of firms		**7,812**	**100.00**

* 4 firms from SVE were not georeferenced. Source: SABI.

Table 2.1 shows that the most important creative industries in the MAB include Architecture and engineering, Advertising and related services, Graphic arts and SVE. This dataset includes 7,812 creative firms located in the MAB with available information on the address of the headquarters, data about the number of employees and operating in 2015.[14] Table 2.2 summarizes the firm data used in this chapter.[15]

[14] Initially, we compiled 19,229 firms from the province of Barcelona (NUTS 3 level) from the SABI. After some filtering, we discarded 11,491 firms with missing data or which were not located in the MAB, and to this dataset (7,738) we added 74 Video game firms in order to obtain a final dataset of 7,812 creative firms.

[15] The firm level data includes location, age and number of employees.

Table 2.2 Number of firms' summary

	Video Game firms (104)		**SVE firms (1984)**	
	With all data	**With missing data**	**With all data**	**With missing data**
Catalonia	87	17	1984	0
MAB	70	4	854	4
Barcelona	54	0	640	0

Source: Own Elaboration. Note: Video Game firms (104) are included in SVE firms (1984).

2.3.2 Methodology

In order to analyse the location patterns of SVE in the MAB, we used several techniques including Spatial Autocorrelation analysis, Nearest Neighbour Index (NNI) and M-functions. All these techniques can be used together in order to identify firms' location patterns, because they do not measure exactly the same dimensions.[16] While Spatial Autocorrelation analysis focuses on spatial autocorrelation through geographical units (e.g. neighbourhoods) and shows results for these geographical units, NNI analyses the spatial concentration of points (e.g., firms) in a territory, and does not take into account whether firms are in different geographical units, and M-functions analyses agglomeration (from the same industry) and co-agglomeration (between two industries) of firms by considering their number of employees. When used together, these techniques provide us with an overall spatial approach for different industries at several levels.

[16] The main aim of this paper is not the analysis of the role of real estate prices but the analysis, in general terms, of location patterns (i.e., rather than location determinants). It is obvious that real estate prices are relevant, but their influence over firms' location is out of the scope of this analysis. Although real state prizes may affect all types of firms (even in a different way), in this paper we are mainly interested in spatial linkages among location patterns of firms from different industries.

Spatial autocorrelation (Moran's I and LISA)

Figure 2.2 suggests that SVE firms are clustered in some areas of the MAB and specifically, in Barcelona, but we needed to check if this pattern really existed by using Moran's I and the Local Index of Spatial Association (hereinafter LISA).

Before calculating spatial autocorrelation, it necessary to define a spatial-neighbour matrix (W) in order to identify neighbourhood patterns among spatial units. We will use the 73 neighbourhoods defined by Barcelona's city council and we will consider that two neighbourhoods are neighbours if they share a common border.[17]

Once W has been identified, we calculate two measures of spatial autocorrelation: Moran's I (Moran, 1948) and LISA (Anselin, 1995). The values of Moran's I indicate a negative spatial autocorrelation if they range from -1 to 0; a positive spatial autocorrelation if they range between 0 and 1; and a random distribution if they are around 0. LISA identifies whether spatial autocorrelation is geographically constrained to certain areas (i.e. neighbourhoods).

Nearest Neighbour Index (NNI)

The Nearest-Neighbour Index (Clark and Evans, 1954) is an indicator that compares the mean of the observed distance between each point (e.g. SVE firms) and its nearest neighbour with the expected mean

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[17] There are several alternative definitions for neighbours (k-nearest neighbours, contiguous neighbours, or distance-based neighbours, among others) but considering that this is an intraurban analysis in which neighbourhoods are quite close to each other in a defined space (Barcelona) we considered that the most appropriate measure is contiguity.

distance if a spatial random distribution is assumed. The NNI is formulated as follows:

$$NNI = \frac{Observed\ Average\ Distance}{Expected\ Average\ Distance}$$

Where Observed Average Distance and Expected Average Distance are defined as:

$$Observed\ Average\ Distance = \frac{\sum_{i=1}^{n} d_i}{n}$$

$$Expected\ Average\ Distance = 0.5\sqrt{\frac{A}{n}}$$

, where *d* is the distance, *n* is the number of neighbour links and *A* is the total area of the region considered. The values of NNI are interpreted as follows: values around 0 indicate a clustered pattern, values around 1 indicate a random distribution of the points, and values higher than 2 indicate a uniform pattern (the maximum possible value is 2.15 for a hexagonal grid). NNI has been used previously (Rehák and Chovanec, 2012) to analyse the location patterns of creative industries in Slovakia.

M-functions

M-functions (Marcon and Puech, 2010) enable the capture of spatial clustering and are of increasing interest to researchers, although some previous related measures are worthy of attention, such as Ripley's K. This function was developed by Ripley (1976) and computes the density of any set of points (i.e., firms) for a given radius of distance in order to control if there is clustering at certain distances. Distance radii are calculated around every point, and K(d) is the mean density of points for every distance radius (d) and this density is divided by the mean density of the n points in the area (a) as a whole: n/a. At first glance, the interpretation of Ripley's K seems to be quite similar to that of NNI, when the expected random values are compared with observed values. If the observed values exceed the expected values, there is a clustered pattern; and if the observed values are lower than the expected values, there is a dispersed pattern.

Later, M-functions were introduced by Marcon and Puech (2010) as a cumulative function. This function is cumulative as K, but in contrast to Ripley's K, the ratio of local to mean density is replaced by the ratio of local to global proportions of the sector of interest to the whole industry (Marcon and Puech, 2017). These functions can evaluate the geographic intra-industry agglomeration of a given industry or the co-agglomeration between two industries, using the number of employees as a weight measure. A more in-depth explanation of these functions can be found in the Appendix A.

Numerous papers use the M-functions as a tool to explain concentration, agglomeration and dispersion patterns between industries such as Moreno-Monroy and Cruz (2015), who use this distance-based method to measure the agglomeration patterns of formal and informal manufacturing activity within the metropolitan area of Cali. Likewise, Coll-Martínez et al. (2019) analyse spatial patterns of agglomeration of creative industries in the Metropolitan Area of Barcelona using *M* and *m* functions.

The values of these functions are represented in a plot graph, indicating an M-value for each distance, whose confidence interval is built by relocating firms to all actuals location, regardless their sector of activity. The M-value indicates the density of employment for each distance (e.g., a M-value of 2 in 1 km of distance means that the density of employees in the industry *i* in a radius of less than 1 km is 2 times greater than what can be observed in all the area). If the M-value is outside the confidence interval (shadow area) at the top of the plot, then there is concentration (intra-industry) or agglomeration (inter-industry), and if the M-value is outside the confidence interval at the bottom of the plot, then there is dispersion of the industry (intra-industry) or between industries (inter-industry). If M-values are inside the confidence interval, then the results are not conclusive.

2.4 Results

2.4.1 Some descriptive statistics

Table 2.3 presents some descriptive statistics for Video Game firms (74), SVE firms (858 firms that include Video Game firms) and creative firms (7,812 firms that include SVE and Video Game firms) located in the MAB. These firms are obtained from the firm's data with the age and number of workers available (firms with missing values were not included in the analysis). Table 2.3 shows that firms in the Video Game industry are younger (5.7 years old on average) than SVE firms (13.0) and the creative industries as a whole (16.0), and they are also larger (21.3 workers on average) than their counterparts in the SVE (19.1) and creative industries (10.8).

Table 2.3 Statistical descriptive information

	Mean	Standard Deviation	Min	Max	Median
Video Game firms					
Workers	21.3	59.5	1	400	5
Age	5.7	4.8	0	22	4
Number of firms	74				
SVE firms					
Workers	19.1	75.5	1	1,329	4
Age	13.0	7.6	0	62	12
Number of firms	858				
Creative firms					
Workers	10.8	58.9	1	2,480	2
Age	16.0	9.6	0	144	14
Number of firms	7,812				

Source: SABI, *Institut Català de les Empreses Culturals* and own elaboration.

2.4.2 Agglomeration of SVE industry

We will begin the analysis by focusing on whether SVE firms tend to locate together (NNI) in a small number of locations or on the contrary, tend to disperse. We will then analyse whether previous patterns may be part of a spatial dependence process, and we will check this using global (Moran's I) and local (LISA) measures. Finally, we will use a distance-based method of spatial concentration (M-function) to quantify previous concentration patterns and identify their spatial scope, and to check whether there is any evidence on co-agglomeration between pairs of industries.

The results in Table 2.4 indicate that there is some evidence of clustering for both Video Game firms (NNI value of 0.47660) and all SVE firms (0.33428) in the MAB, but the phenomenon is stronger in the latter case. Nevertheless, as we are particularly interested in Video

Game firms, we want to analyze whether this clustering is related to firm's specific characteristics, and as such we have grouped Video Game firms on the basis of age (new firms vs. old ones) and size (young firms vs. big ones)[18]. Our results show that clustering mainly takes place among young (NNI value of 0.47140 vs. 0.63081) and small (0.54472 vs. 0.84070) firms.

Table 2.4 Nearest Neighbor Index from SVE and Video Game firms in the MAB

			Video Game firms Age		Video Game firms Size	
	All SVE firms	**Video Game firms**	**Old firms (> 6 years)**	**New firms (≤ 5 years)**	**Big firms (> 3 workers)**	**Small firms (≤ 3 workers)**
Average observed distance*	184.558	811.614	1452.011	996.173	2135.768	1117.359
Average expected distance*	551.453	1703.278	2302.538	2113.531	2528.233	2052.383
Nearest neighbor index	0.33428	0.47660	0.63081	0.47140	0.84070	0.54472
Number of observations	854	70	34	36	25	45
Z-Value	-37.21748*	-8.37739*	-4.11767*	-6.06745*	-1.52290**	-5.84268*

Significance levels: (*): p<0.01 (**): p<0.1. *The distances are in meters. Source: Own elaboration.

[18] The cut-off point of firms' ages was obtained by the median, whereas for size we considered that firms with more than 3 employees were not small firms by this industry's standards (the median size is 5 employees).

According to these results, we confirm our main hypothesis, since these firms locate close to each other and clustering appears to be a competitive strategy for younger and smaller firms that need spatial proximity with similar firms in the same industry in order to benefit from positive agglomeration externalities. For instance, this implies a stronger propensity to locate in business incubators or in/around technological research centres. Similarly, it is also reasonable to assume that older and bigger firms may have internalized some of these external resources, and are less dependent on these agglomeration externalities. This is a well-established effect, which is also known as liability of newness and liability of smallness (Agarwal et al., 2002). These results are consistent with those of Slach et al. (2015), as they show a similar degree of clustering for this type of industry, and the results of Rehák and Chovanec (2012) who show that these industry tend to be clustered in big cities, as we show here.

Table 2.5 Districts, Neighbourhoods and number of firms by Neighbourhood

District	NBH	SVE	VDG	District	NBH	SVE	VDG
Ciutat Vella	**1**	4	1	Horta-Guinardó (cont.)	**38**	1	0
	2	8	0		**39**	0	0
	3	0	0		**40**	1	0
	4	6	0		**41**	7	1
Eixample	**5**	8	0		**42**	0	0
	6	12	0		**43**	3	1
	7	107	8	Nou Barris	**44**	2	1
	8	52	4		**45**	3	0
	9	32	3		**46**	1	0
	10	13	0		**47**	0	0
Sants-Montjuïc	**11**	1	0		**48**	7	2
	12	3	0		**49**	0	0
	13	2	0		**50**	0	0
	14	2	0		**51**	0	0
	15	2	0		**52**	2	0
	16	2	0		**53**	0	0
	17	4	0		**54**	0	0
	18	6	1		**55**	0	0
Les Corts	**19**	43	4		**56**	0	0
	20	7	0	Sant Andreu	**57**	0	0
	21	10	0		**58**	0	0
Sarrià-Sant Gervasi	**22**	0	0		**59**	1	0
	23	10	0		**60**	3	1
	24	6	0		**61**	10	3
	25	11	1		**62**	2	1
	26	62	4		**63**	2	0
	27	9	1	Sant Martí	**64**	6	1
Gràcia	**28**	7	0		**65**	4	0
	29	1	0		**66**	37	4
	30	6	0		**67**	10	1

	31	25	2		**68**	15	1
	32	10	1		**69**	16	2
Horta-Guinardó	**33**	12	0		**70**	1	0
	34	1	0		**71**	15	5
	35	2	0		**72**	3	0
	36	2	0		**73**	0	0
	37	0	0	**TOTAL**		640	54

Note: "NBH" indicates neighbourhoods (a list of neighbourhood names can be found in Table A2.12, in the Appendix B), "SVE" is the number of SVE firms and "VDG" is the number of Video Game firms. Source: Own elaboration.

Having identified a clustering pattern we need to identify whether this is due to a spatial dependence process. Our empirical strategy will start at regional level, taking into account municipalities in the MAB and districts (10) in Barcelona, as *i)* according to their size they are reasonably comparable to all the municipalities in the MAB apart from Barcelona, and *ii)* using the entire city of Barcelona as a spatial aggregation area may lead to bias in the results, as this city is much larger than the other municipalities in the MAB. As most SVE and Video Game firms are located in Barcelona, we will then focus on this city at neighbourhood level (73 neighbourhoods). There are 640 SVE firms (including 54 Video Game firms) located in the city of Barcelona, as shown in Table 2.5. Most are located in the districts of Eixample (35.0% of SVE firms and 27.8% of Video Game firms), Sant Martí (16.7% and 25.9% respectively) and Sarrià-Sant Gervasi (15.3% and 11.1% respectively).

The values for Moran's I indicate that there is positive spatial autocorrelation for SVE firms, in both the MAB as a whole (0.3484) and in the city of Barcelona (0.3617). For Video Game firms, although there is still a positive autocorrelation for both areas, the values are lower (0.2886 for the MAB and 0.1680 for Barcelona) and close to a random pattern for the case of Barcelona. Taking both areas and industries into account, our results show that there are various agglomeration mechanisms that may be caused by specificities of these industries and geographical areas. Even if it seems reasonable to anticipate higher levels of spatial autocorrelation in a more homogeneous area like Barcelona, the results for Video Game firms may be explained in terms of the large number of firms located in Sant Cugat del Vallès, a high-income city located close to Barcelona that is home to an important number of high-tech activities, including firms, research centres and research parks.[19]

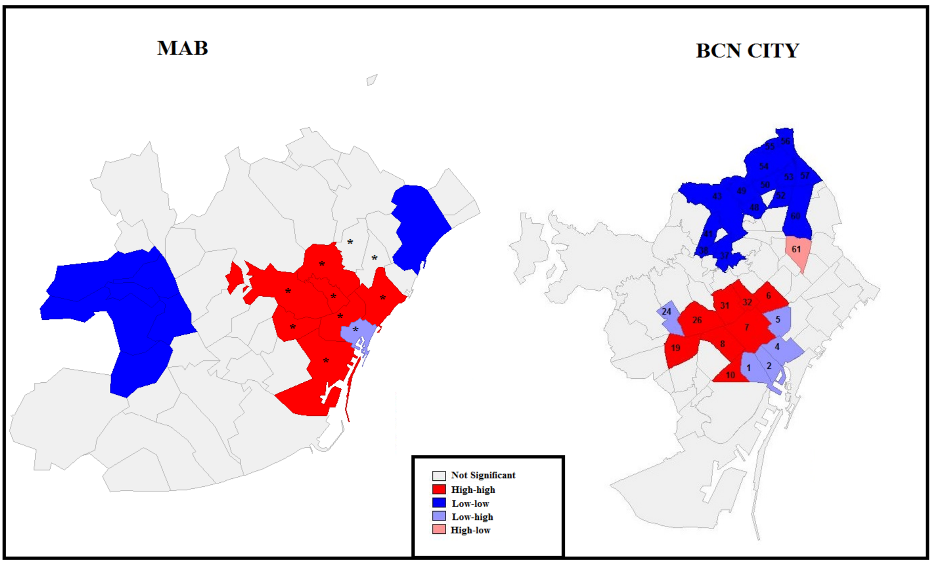
Whilst Moran's I provides an overview of the spatial autocorrelation of location patterns of firms, LISA allows a more in-depth examination of the geographical specificities of this phenomenon[20]. Figure 2.3 shows the LISA results for SVE firms for both the MAB (left-hand side) and Barcelona (right-hand side). The results for the MAB clearly show that there is a high-high spatial autocorrelation at the core of the area (i.e., areas hosting a large number of firms are neighbours) that is mostly in Barcelona (i.e. including 7 of its 10 districts), whilst there is a low-low spatial autocorrelation area (i.e. areas hosting a small number of firms are neighbours) in the western municipalities of the MAB, which are mainly residential. After noting this phenomenon in Barcelona, the next

[19] This effect on the level of the MAB is due to the large number of firms located in Barcelona and to the proximity of Sant Cugat del Vallès to Barcelona, which are the second- and first-ranked municipalities in terms of the number of Video game firms (the two municipalities have more than 80% of the Video game firms situated in the MAB), producing this Moran's I value, which is higher than the level for the city of Barcelona.

[20] The calculations were made using a 0.05 significance level and 499 permutations.

stage is to analyse the LISA results for the city in order to identify the areas (i.e. neighbourhoods) where this high-high spatial autocorrelation exists. The right-hand side of Figure 2.5 shows that spatial dependence of neighbourhoods with a large number of firms (i.e. red areas) is mainly on both sides of the Avinguda Diagonal, Barcelona's main traffic route, in areas in/around the CBD and where most of the university faculties are located, whilst the opposite (i.e. blue areas) are mainly found in low-income neighbourhoods in the east of the city where the land use is mainly residential rather than economic. Our results show that there is no agglomeration in the Poblenou neighbourhood (see the right-hand map in Figure 2.3) and the surrounding areas as 22@, which shows that SVE firms prefer other central areas in the city (see Viladecans-Marsal and Arauzo-Carod, 2012).

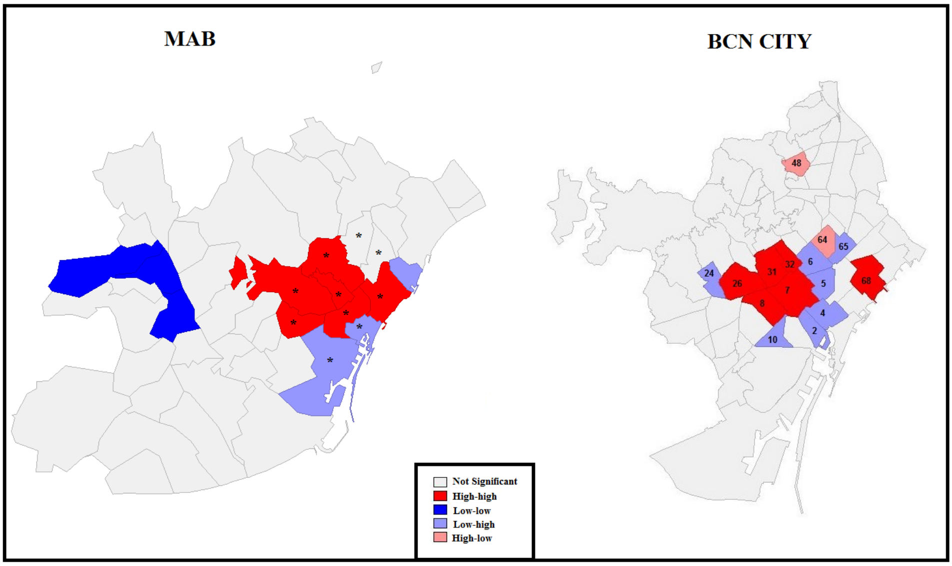
Figure 2.3 LISA for the MAB and Barcelona (SVE firms)



N.B.: The numbers denote the neighborhoods' codes. Source: Own elaboration. (*) Barcelona city districts.

Figure 2.4 shows the same analysis for Video Game firms and unsurprisingly provides similar results, as at the MAB level there is an area of high-high spatial autocorrelation (i.e. red areas) for most of the districts of Barcelona (6 out of 10) and a low-low area (i.e. blue areas) in the western residential municipalities of the MAB. For the city of Barcelona, the results for Video Game firms show a similar high-high pattern in the CBD neighbourhoods on both sides of the central section of the Avinguda Diagonal and in the Poblenou neighbourhood, an area that has received special attention from Barcelona City Council thanks to the 22@ project (see Viladecans-Marsal and Arauzo-Carod, 2012).

Figure 2.4 LISA for the MAB and Barcelona (Video Game firms)



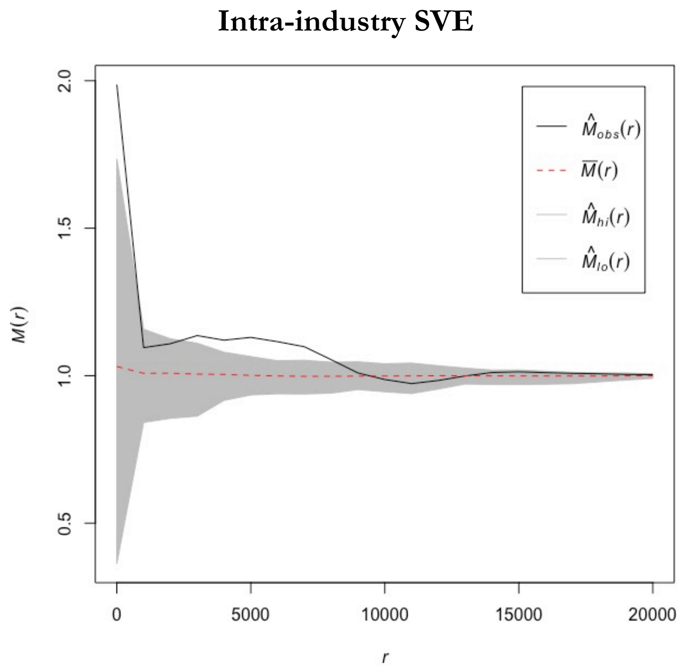
N.B.: The numbers denote the neighborhoods' codes. Source: Own elaboration. (*) Barcelona city districts.

At this stage, when concentrations of SVE and Video Game firms have been identified for both the MAB and Barcelona, the next step is to use M-functions to quantify the spatial scope of these location patterns (i.e. the intra-industry level) and to check if there is any evidence for co-agglomeration between pairs of industries (i.e. the inter-industry level). We will analyse the inter-industry location linkages of SVE firms with some other creative industries (Advertising and related services, Publishing, Graphic Arts and Video and Film industries) that we suspect tend to collocate with them. First of all, we analyse the intra-industry effects and then the inter-industry effects.[21]

Figures 2.5 and 2.6 respectively show the M-functions at the intra-industry level for the SVE industry and Video Game industry. The results for SVE suggest a high concentration of firms from that industry (at the peak the concentration is almost twice that observed in the area as a whole) in a radius of around 7.5 km. This result means that when comparing relative density of employees of the SVE industry around each firm belonging to that industry, the density is 2 times greater than what can be observed in all the MAB. The data shown in Figure 2.5 corroborate the previous results from the NNI and spatial autocorrelation tools, but M-functions enable this clustering pattern to be quantified by determining the mean peaks around firms for the industry (i.e. twice the mean density) and the spatial range of this phenomenon (i.e. up to 7.7 km).

[21] All calculations were made at a 0.05 significance level, using 150 simulations.

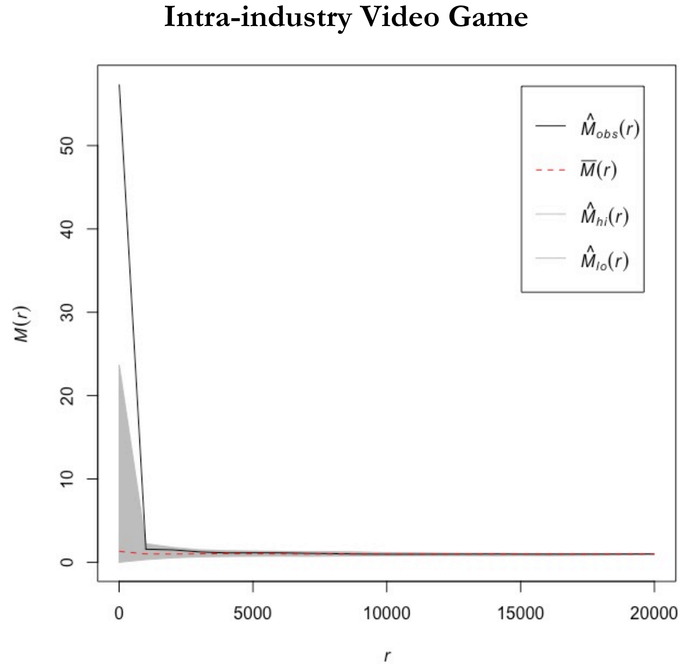
Figure 2.5 Intra-industry agglomeration of the SVE industry in the MAB



Horizontal axis units (*r*): meters. Source: Own elaboration.

The Video Game industry (Figure 2.6) has a remarkable concentration that peaks at about 60 times the expected density of employees for close distances, then declines rapidly and within a radius of roughly 1 km. In this case, our results indicate that intra-industry linkages occur at very short distances, as firms in the Video Game industry have similar needs in terms of their location determinants. Nevertheless, it is important to note that this result does not imply that all firms from this industry are located in the same place or only at very short distances from each other. It means that firms cluster, although they may cluster in different places.

Figure 2.6 Intra-industry agglomeration of Video Game firms in the MAB



Horizontal axis units (*r*): meters. Source: Own elaboration.

In terms of inter-industry effects, Table 2.6 summarizes the inter-industry relations of SVE and Video Game respectively, with some pairs of industries (all Creative industries, Advertising and related services, Publishing, Graphic arts, and Video and film industries). In general terms, most of these pairs have no significant co-agglomeration (or dispersion) effects (especially for Video Game), which suggests that these firms do not tend to co-agglomerate around the selected creative industries and vice-versa.

Table 2.6 Inter-Industry effects summary

Categories	SVE Firms	Video Game Firms
All Creative	Dispersion	Dispersion
Advertising and related services	Co-agglomeration	*Not significant*
Publishing	*Not significant*	*Not significant*
Graphic arts	Dispersion	*Not significant*
Video and film industries	Co-agglomeration	Agglomeration
SVE	-	*Not significant*
Video Game	*Not significant*	-

Source: Own elaboration.

Nevertheless, there are some exceptions in which co-agglomeration/dispersion effects are present.[22] For SVE, there are mild co-agglomeration effects with Advertising and related services (see Figure A2.3). The relative density of employees in Advertising and related services firms located around SVE firms is higher (around a radius of 6 km) than that observed for the whole area, whilst there is a similar result for SVE firms around Advertising and related services firms but between an approximate radius of 2 and 7 km. The same pattern is observed for Video and film industries firms locating around SVE firms (see Figure A2.9) but at a radius of 9-10 km, and for SVE firms locating around Video and film industries firms the agglomeration is identified as a radius of between 2 and 7 km. There is also empirical evidence of dispersion effects. When the location patterns of SVE firms and all creative industries firms are analysed together, there is consistent empirical evidence of a dispersion effect of all creative industries firms around SVE firms, as the relative density of employees in all creative industries firms is smaller in a 9 km radius than that observed for the

[22] The M-function graphs (from A2.1 to A2.11) summarised in Table 2.6 are provided in the Appendix B.

whole area, whilst the opposite is also true (i.e. dispersion of SVE firms around all creative industries firms) but only in a radius of roughly 1 km (see Figure A2.1). There are also dispersion effects when the location patterns of SVE firms and Graphic arts are compared. These effects are especially important for Graphic arts firms located around SVE firms, as the relative densities of employees are lower than for the whole area in a radius of 20 km, whilst when SVE firms around Graphic arts firms are analysed (see Figure A2.7), the radius for which dispersion effects are reported is about 6 km.

For Video Game firms, there is significant evidence for the Video and film industries (agglomeration) and for all creative industries (dispersion). Agglomeration effects are found mainly for firms in the Video and film industries around Video Game firms (see Figure A2.9), with a peak relative density of employees corresponding to a M-value of 1.5, which means that density in this area (i.e., inside a 2 km radius) is 50% higher than for the area as a whole. There are dispersion effects between all creative firms and Video Game firms in both directions over very short distances (see Figure A2.2). These results confirm as well our main hypothesis, since it seems that SVE and, in particular, Video Game firms cluster in few core locations and co-locate with related firms, benefited by knowledge spillovers.

2.5 Conclusions

This chapter is consistent with the main tenets of recent empirical literature analysing location patterns of specific industries at very detailed geographical levels, and shows that SVE and Video Game firms follow similar patterns to other service industries by tending to cluster around some central areas of the Metropolitan Area of Barcelona (MAB) as a whole, and Barcelona city centre in particular. We have focused these industries in view of their strategic relevance for more developed economies, and also because they tend to cluster in and around large urban areas (i.e. the MAB hosts around 67% of Video Game firms operating in Catalonia), attracted by their environment with creative know-how, a skilled workforce, educational institutions providing specialized training programs and internationally renowned professional events such as *Barcelona Games World 2016*. However, very little was known about their specific location patterns and in particular, whether they tend to co-locate close to other creative industries.

The results confirm our main hypothesis, as we show how and where SVE firms cluster in few core locations. In this sense, we also show that firms' characteristics partially help to explain their location preferences, as smaller/younger firms behave in a different way to larger/older firms. We also tested whether the location of firms for these industries is spatially autocorrelated, using both global (Moran's I) and local measures (LISA). Moran's I indicates a moderate spatial correlation for SVE industries at the level of the MAB and the city of Barcelona, whilst for the Video Game industry evidence it is even smaller in both cases, and there is almost no difference between the MAB and Barcelona.

Nevertheless, local measures are of great interest as they highlight some similarities and differences for both industries. First, the main similarities arise from high-high levels of association in the central neighbourhoods (mainly around Barcelona's main traffic route, Avinguda Diagonal) and in the 22@ neighbourhood. Second, the main differences are in terms of low-low association areas, because whereas for the SVE industry there is a big area in low-income districts located north-east of the city, there is no similar phenomenon for Video Game firms, for which there is no significant low-low area.

The M-function results validate previous conclusions from spatial autocorrelation measures and suggest further insights for both industries. In specific terms, they contextualize the SVE and Video Game industry in terms of creative industries' location patterns. Surprisingly, the two industries are not clustered around the whole range of creative industries, which is a result that suggests some degree of heterogeneity of locational preferences in high-tech creative activities of this type. A more in-depth examination of the classification of creative industries shows that the patterns differ between the SVE and, noticeably, Video Game firms. Namely, whilst for the former there is a significant clustering pattern with Advertising and related services and Video and film industries, and a dispersion pattern with Graphic arts and all creative industries; for the latter there is neither a clustering or dispersion pattern (except for some agglomeration with the Video and film industries, and some dispersion with all creative industries). These results indicate that inter-industry interactions of the SVE and Video Game firms differ as, in general terms, they do not tend to locate close the same type of industries. A possible interpretation about underpinnings of such behaviour may rely on knowledge flows across firms (that differ across sectors) explained in terms of knowledge complementarities at industry level. In this sense, we suspect that firms' locational revealed preferences are driven by expectations of these potential knowledge transfers.

This analysis obviously suffers from some limitations that need to be resolved in future research. Firstly, as we have focused on the official definition of the MAB we only considered 36 municipalities, but there are alternative classifications of the same area from a functional point of view, which include a larger number of municipalities[23]. Secondly, as these are very dynamic industries and turnover is of high importance, it is not at all clear whether the entire universe of firms has been captured in our datasets.

Our results have important implications for policies aiming to attract and encourage the local development of firms in the SVE industries, as they provide some key facts about the locational preferences of firms in these industries. Although both industries are concentrated in and around the MAB, the concentration of Video Game industry is noticeable in the city centre of Barcelona and particularly around two subcentres located *i)* on both sides of the Avinguda Diagonal and *ii)* in the 22@ district. It is important that policymakers take these firms' preferences into account in order to provide some specific services and help to improve accessibility to required inputs (e.g., research centres,

[23] For further details, see "Las Grandes Áreas Urbanas y sus municipios 2015" at http://www.fomento.gob.es/NR/rdonlyres/416CE7FD-A6B0-431D-881B-D1F07664795E/133984/listado__2015_2.pdf.

incubator services, accessibility to skilled labour, forums where to interact with other firms, etc.), which could make Barcelona an even more appealing destination for them. As the Video Game industry is rapidly growing worldwide, the challenge for local policymakers is to continue attracting new firms and related activities that could enhance the competitiveness of Barcelona's cluster.

We will leave the analysis of whether our conclusions hold for alternative definitions of the MAB (as well as alternative data sources about firms in those industries) for future research.

Appendix A

M-functions:

For the intra-industry location analysis, we define the expression for a particular industry *S* as:

$$M_S(r) = \sum_{i=1}^{N_S} \frac{\sum_{i=1, i\neq j}^{N_S} c_S(i,j,r)x_j}{\sum_{j=1, i\neq j}^{N} c(i,j,r)x_j} \Big/ \sum_{i=1}^{N_S} \frac{X_S - x_i}{X - x_i}$$

, where N_S is the total number of firms in the industry *S*, the numerator calculates the relative weight of industry *S* by comparing it with all the activity inside circles of radius *r*, as $c_s(i,j,r)$ is a dummy variable that takes the value 1 whether the distance between *i* and *j* firms in industry *S* is less than the radius *r*. For all activities, we define a dummy *c(i,j,r)* as equal to 1 if firm *j* (in any industry) is located at a distance less than or equal to *r* from firm *j*. The denominator is the relative size of the industry *S* compared to all activities, X_S is the number of employees of the industry *S*, *X* is the same but for all industries, x_i and x_j are the number of employees for the firm *i* and *j*. M values higher than 1 ($M_S(r)>1$) therefore indicate that there are more employees of firms in industry *S* in a radius of *r* than in the area as whole, values equal to 1 indicate the same location pattern for the industry *S* in the whole area, and values lower than 1 ($M_S(r)<1$) show dispersion, indicating fewer employees of industry *S* in a radius of *r* around the establishments than in the area as a whole.

For the inter-industry analysis (co-location) we use the following expressions:

$$M_{S_1,S_2}(r)=\sum_{i=1}^{N_{S_1}}\frac{\sum_{i=1}^{N_{S_2}}c_{S_2}(i,j,r)x_j}{\sum_{n=1,i\neq n}^{N}c(i,j,r)x_n}\Big/\sum_{i=1}^{N_{S_1}}\frac{X_{S_2}}{X-x_i}$$

The expression above represents the spatial distribution of firms belonging to industry S_2 around industry S_1, evaluating whether the relative density of employees from one industry around employees of another industry is on average ($M_{S1,S2}(r)=1$), higher ($M_{S1,S2}(r)>1$) or lower ($M_{S1,S2}(r)<1$).

Likewise, and in the opposite direction, we can analyse the following expression:

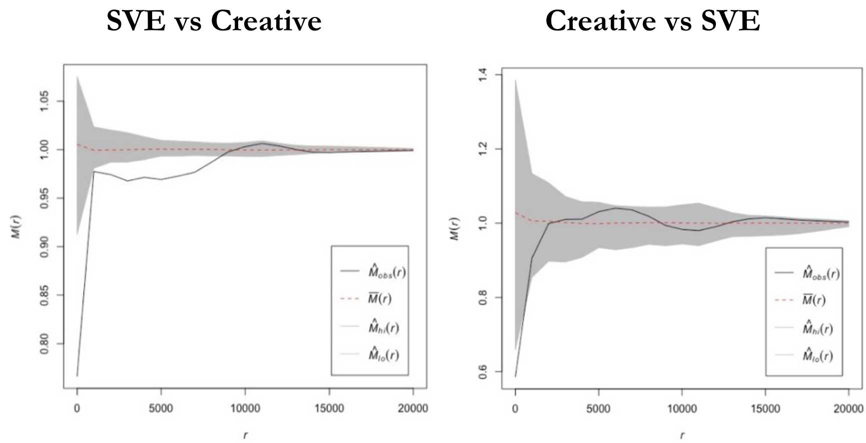
$$M_{S_2,S_1}(r)=\sum_{i=1}^{N_{S_2}}\frac{\sum_{i=1}^{N_{S_1}}c_{S_1}(i,j,r)x_j}{\sum_{n=1,i\neq n}^{N}c(i,j,r)x_n}\Big/\sum_{i=1}^{N_{S_2}}\frac{X_{S_1}}{X-x_i}$$

which represents the spatial distribution of firms belonging to industry S_1 around industry S_2, evaluating if the relative density of employees from one industry around employees of another industry is on average ($M_{S2,S1}(r)=1$), higher ($M_{S2,S1}(r)>1$) or lower ($M_{S2,S1}(r)<1$). In order to obtain a conclusive result, both values ($M_{S1,S2}(r)$ and $M_{S2,S1}(r)$) have to be in the same direction (both values higher than one indicates an agglomeration effect between industries, less than 1 a dispersion effect between industries, and both equal to 1 an average of employees across industries between them).

Appendix B

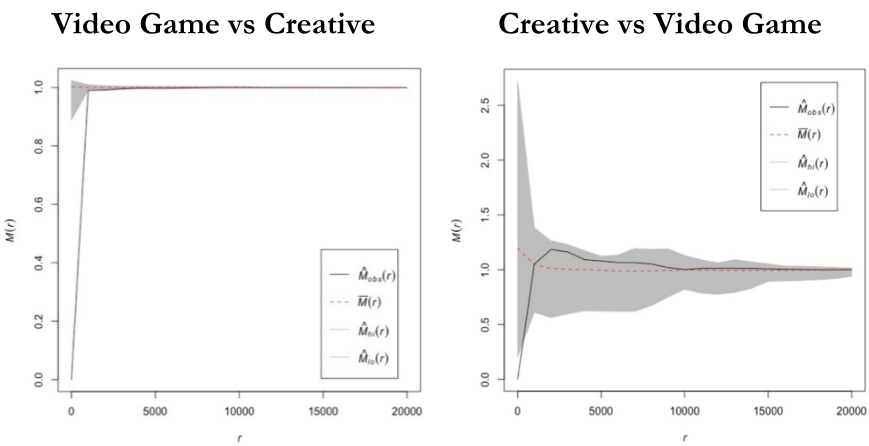
See Figures A2.1 to A2.11 and Table A2.12.

Figure A2.1 Inter-Industry co-agglomeration: Software, Video Game and editing electronics vs. Creative in the MAB



Horizontal axis units (*r*): meters. Source: Own elaboration.

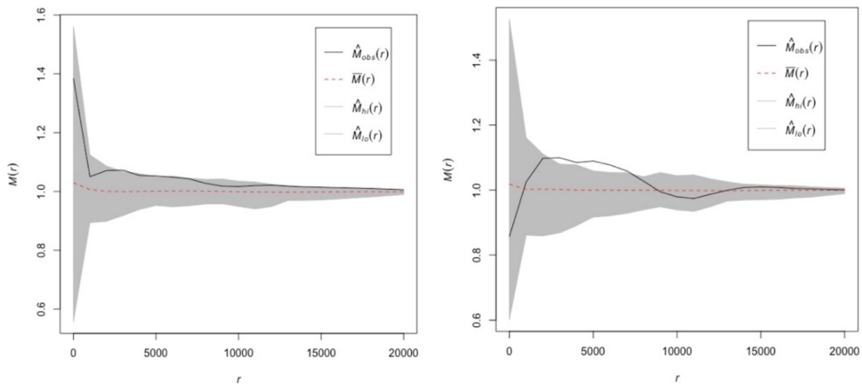
Figure A2.2 Inter-Industry co-agglomeration: Video Game vs. Creative in the MAB



Horizontal axis units (*r*): meters. Source: Own elaboration.

Figure A2.3 Inter-Industry co-agglomeration: Software, Video Game and editing electronics vs. Advertising and related services in the MAB

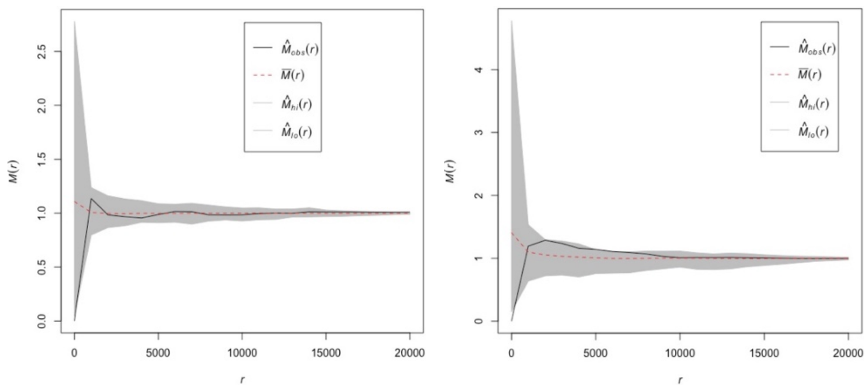
SVE vs ADV **ADV vs SVE**



Horizontal axis units (*r*): meters. Source: Own elaboration.

A2.4 Inter-Industry co-agglomeration: Video Game vs. Advertising and related services in the MAB

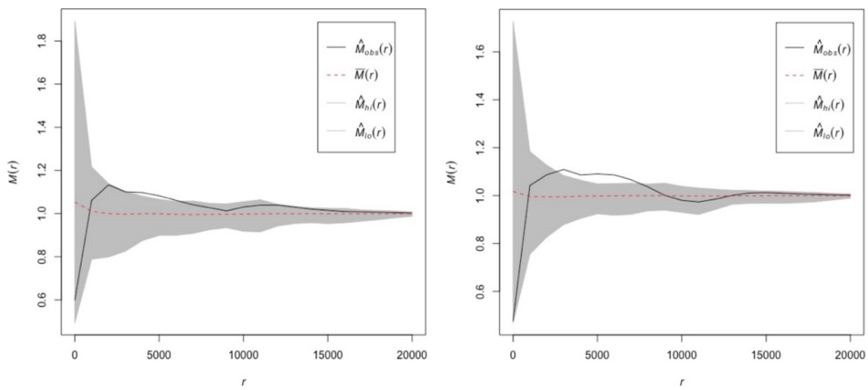
Video Game vs ADV **ADV vs Video Game**



Horizontal axis units (*r*): meters. Source: Own elaboration.

Figure A2.5 Inter-Industry co-agglomeration: Software, Video Game and editing electronics vs. Publishing in the MAB

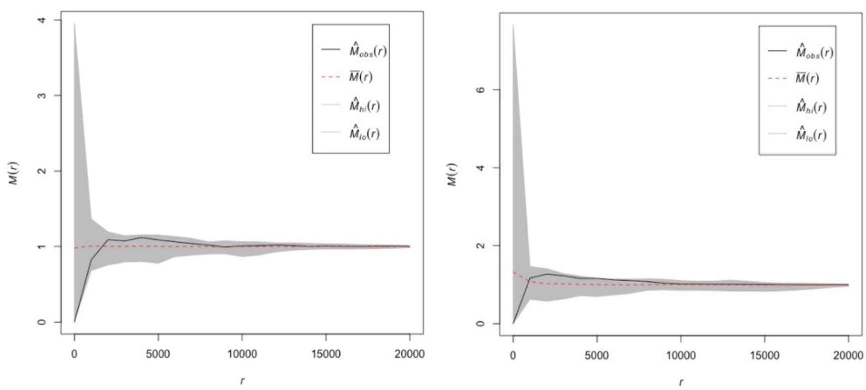
SVE vs ED | **ED vs SVE**



Horizontal axis units (*r*): meters. Source: Own elaboration.

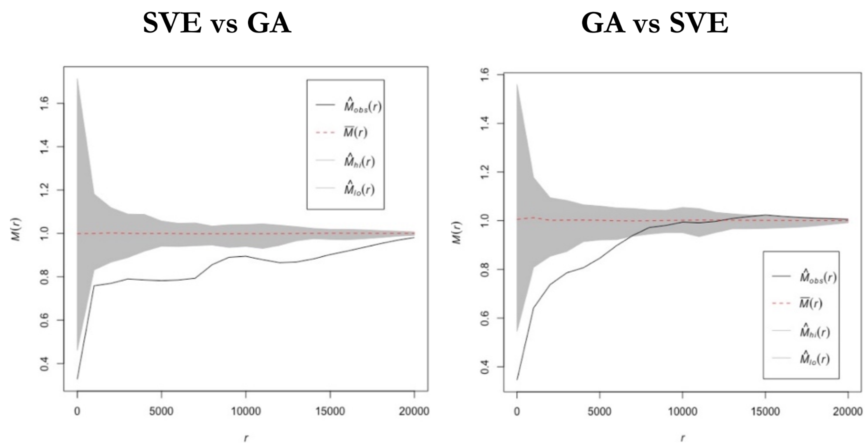
Figure A2.6 Inter-Industry co-agglomeration: Video Game vs. Publishing in the MAB

Video Game vs ED | **ED vs Video Game**



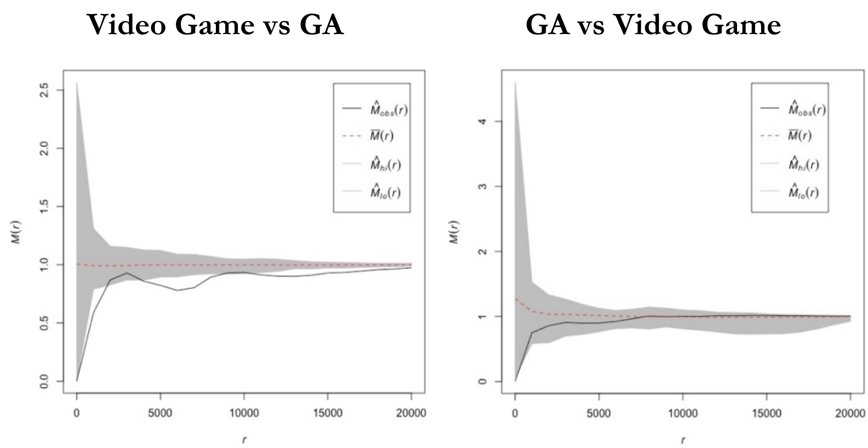
Horizontal axis units (*r*): meters. Source: Own elaboration.

Figure A2.7 Inter-Industry co-agglomeration: Software, Video Game and editing electronics vs. Graphic Arts in the MAB



Horizontal axis units (*r*): meters. Source: Own elaboration.

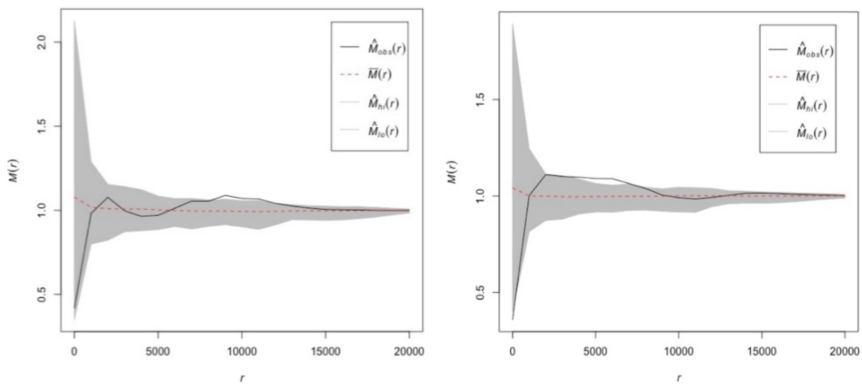
Figure A2.8 Inter-Industry co-agglomeration: Video Game vs. Graphic Arts in the MAB



Horizontal axis units (*r*): meters. Source: Own elaboration.

Figure A2.9 Inter-Industry co-agglomeration: Software, Video Game and editing electronics vs. Video and Film industries in the MAB

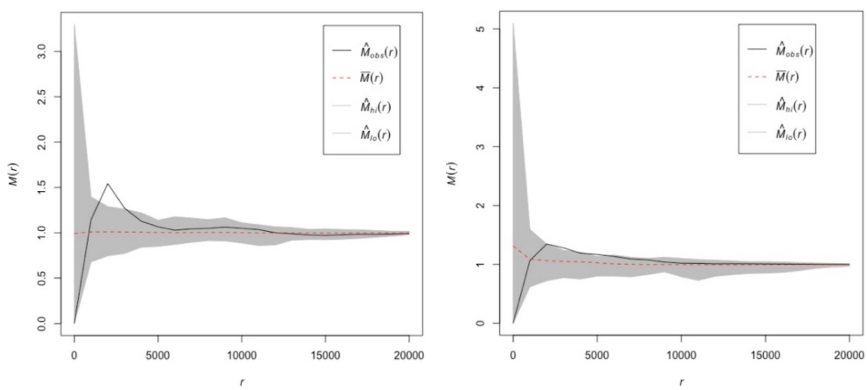
SVE vs VFI **VFI vs SVE**



Horizontal axis units (*r*): meters. Source: Own elaboration.

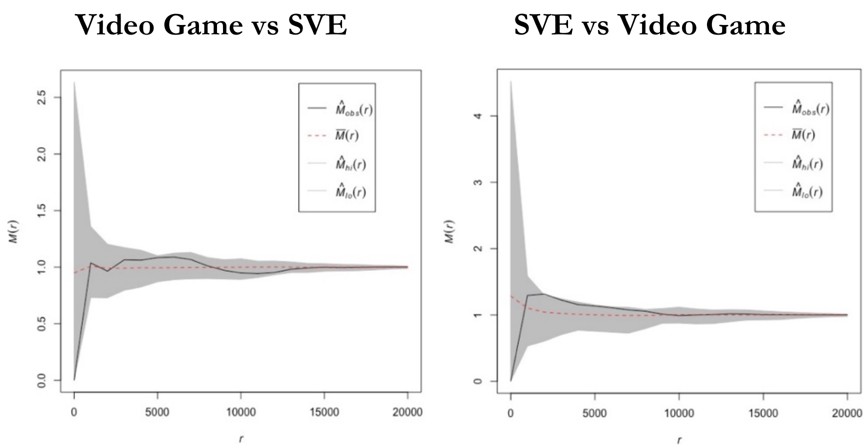
Figure A2.10 Inter-Industry co-agglomeration: Video Game vs. Video and Film industries in the MAB

Video Game vs VFI **VFI vs Video Game**



Horizontal axis units (*r*): meters. Source: Own elaboration.

Figure A2.11 Inter-Industry co-agglomeration: Video Game vs. Software, Video Game and editing electronics (without Video Game firms) in the MAB



Horizontal axis units (*r*): meters. Source: Own elaboration.

Table A2.12 Neighbourhoods of Barcelona

Code	Name	Code	Name	Code	Name
1	el Raval	26	Sant Gervasi - Galvany	51	Verdun
2	el Barri Gòtic	27	el Putxet i el Farró	52	la Prosperitat
3	la Barceloneta	28	Vallcarca i els Penitents	53	la Trinitat Nova
4	Sant Pere, Santa Caterina i la Ribera	29	el Coll	54	Torre Baró
5	el Fort Pienc	30	la Salut	55	Ciutat Meridiana
6	la Sagrada Família	31	la Vila de Gràcia	56	Vallbona
7	la Dreta de l'Eixample	32	el Camp d'en Grassot i Gràcia Nova	57	la Trinitat Vella
8	l'Antiga Esquerra de l'Eixample	33	el Baix Guinardó	58	Baró de Viver
9	la Nova Esquerra de l'Eixample	34	Can Baró	59	el Bon Pastor
10	Sant Antoni	35	el Guinardó	60	Sant Andreu
11	el Poble Sec	36	la Font d'en Fargues	61	la Sagrera
12	la Marina del Prat Vermell	37	el Carmel	62	el Congrés i els Indians
13	la Marina de Port	38	la Teixonera	63	Navas
14	la Font de la Guatlla	39	Sant Genís dels Agudells	64	el Camp de l'Arpa del Clot
15	Hostafrancs	40	Montbau	65	el Clot
16	la Bordeta	41	la Vall d'Hebron	66	el Parc i la Llacuna del Poblenou
17	Sants - Badal	42	la Clota	67	la Vila Olímpica del Poblenou
18	Sants	43	Horta	68	el Poblenou
19	les Corts	44	Vilapicina i la Torre Llobeta	69	Diagonal Mar i el Front Marítim del Poblenou
20	la Maternitat i Sant Ramon	45	Porta	70	el Besòs i el Maresme
21	Pedralbes	46	el Turó de la Peira	71	Provençals del Poblenou
22	Vallvidrera, el Tibidabo i les Planes	47	Can Peguera	72	Sant Martí de Provençals
23	Sarrià	48	la Guineueta	73	la Verneda i la Pau
24	les Tres Torres	49	Canyelles		
25	Sant Gervasi - la Bonanova	50	les Roquetes		

Source: *Barcelona City Council.*

Chapter 3

Do Software and Video Game firms share Location Patterns across Cities? Evidence from Barcelona, Lyon and Hamburg[24]

3.1 Introduction

Nowadays, the location patterns of firms in high-tech industries are receiving increasing attention by both academics and policy makers. This interest can be easily explained because, in developed and emerging countries, these activities are growing faster than national average and, consequently, new firms and jobs are being created. Nevertheless, these industries do represent not only an important source of economic growth through firms and jobs, but also a key challenge for the competitiveness of the areas generating and attracting high-tech firms. These high-tech industries contribute strongly to higher growth (markets tend to expand), they demand skilled labour, do not imply intensive land consumption, and do not generate negative environmental effects (Berger and Frey, 2016). There is extensive evidence of the importance of young skilled professionals such as

[24] This chapter is co-authored with J.M. Arauzo-Carod. It has already been published in *The Annals of Regional Science*.

computer programmers or software engineers, for high-tech firms (Autor et al., 2003). In summary, a greater specialisation in these industries is a desirable outcome for most of economies that can satisfy the locational requirements of these firms (but it is important to note that not all potential sites may be suitable). Broadly speaking, worldwide empirical evidence shows that such firms prefer areas with accessibility to the skilled workforce and dense network of high tech-firms (Baptista and Mendonça, 2010) that typically correspond to urban environments and, more specifically, the cores of large metropolitan areas (van Geenhuizen, 2007). This location behaviour does not respond only to some kind of path dependence, but to the fact that knowledge spillovers are a key input for them and that these tend to cluster at urban cores.Despite of the relevance of high-tech industries as a whole, this chapter focuses on a specific subgroup which has experienced a very dynamic trend in recent years and is hypothesized to continue this growth in a similar way over the next few years.25 We refer to Software and Video Game (hereafter SVE) industry, which currently benefit from extremely high growth rates, contribute to myriads of new firms, hire very many of skilled engineers, and tend to locate at urban cores (Lorenzen and Frederiksen, 2008). Concretely, in 2010, SVE's represented 5.4% of world GDP (Dutta and Mia, 2010). In addition to their high-tech profile, SVE's are considered to be among the Creative Industries, which are defined as those economic activities that use creativity as one of the main inputs and that provide tangible (or intangible) goods or services that may generate revenues from trade and/or intellectual property (UNCTAD, 2010). In terms of the location

[25]According to PwC (2018), over the period 2017 to 2022, the Video Game industry is expected to grow at an average annual rate of 20.6%.

patterns of Creative Industries, empirical evidence highlights their strong preference for the central areas of larger cities (Coll-Martínez et al., 2019).

We selected three major European cities, Barcelona, Lyon and Hamburg, together with their metropolitan areas, as case study. These cities are of a similar size, share a common manufacturing heritage, are not capital cities and have put in place relevant city strategies which attempt to orientate economic activities around technology, mostly through ambitious urban renewal policies[26] which have transformed previously low-income neighbourhoods into magnets of knowledge and economic activity generation, based on the attraction of high-technology firms and the endogenous development of local firms.

The main aim of this chapter is to explain how Video Game and Software firms locate in urban areas, focusing on *i*) their materialised preferences in terms of central vs. peripheral locations and considering the role played by urban renewal projects, and *ii*) the agglomeration strategies of these firms (i.e., whether SVE's firms tend to be located close to firms in the same industry or close to other Creative Industries). Our assumption is that, in addition to industry-specific characteristics that determine some external requirements by these firms (such as accessibility to skilled labour or specialised IT suppliers), there are some city-specific characteristics (e.g., urban policies, spatial distribution of economic activity) that also matter, and which shape the location

[26] A detailed approach to the transformations of these cities can be found at Viladecans-Marsal and Arauzo-Carod (2012) (Barcelona), Moriset (2003) (Lyon) and Sepe (2014) (Hamburg).

decisions taken by these firms. However, due to space constraints, this analysis is outside the scope of the current chapter.

The novelty of the chapter arises from its double dimension: *i*) the spatial dimension, three different cities and metropolitan areas being considered in order to check whether agglomeration processes at industry level were shaped by urban specificities and *ii*) the technical dimension, as four different methodologies (Nearest Neighbour Index, Kernel densities, K-density Functions and Entropy Index) were used, which jointly provide a better picture of location patterns.

Our main results show that SVEs have clustered in and around the urban cores of these cities, in a process that has attracted many related activities, such as technical events (e.g., professional exhibitions, gaming conventions) and education programs at local universities. Interestingly, despite their similarities, these cities have some differences in location patterns. Although SVEs locate in the central areas of all three cities, the intensity of centralization varies, firms in Hamburg being strongly agglomerated into central areas, a phenomenon which is weaker for Barcelona and especially so for Lyon. In all three areas, SVEs co-locate close to firms belonging to other creative industries as Radio and TV, and Video and film industries. Although the reasons behind that co-location are beyond the scope of this chapter and are left for future research, it is reasonable to assume that there are not only shared location patterns among SVEs and firms from these industries, but also inter-industry linkages favouring spatial proximity.[27]

[27] See Pablo and Arauzo-Carod (2012) for an analysis of inter-industry linkages and spatial proximity among firms.

The remainder of the chapter is organised as follows. Section 2 reviews *i*) the theoretical and empirical literature on the determinants of a firm's location, focusing on the importance of this industry for these cities, and *ii*) the case of Barcelona, Lyon and Hamburg from an historical and urban renewal strategic point of view. Section 3 describes the data and methodology. Section 4 introduces some descriptive statistics and discusses results and, finally, Section 5 presents the main conclusions.

3.2 Location patterns of the Software industry and common patterns for Barcelona, Lyon and Hamburg

Industry-specific characteristics that influence location decisions have been analysed from a spatial perspective showing that Creative industries tend to agglomerate (e.g., Coll-Martínez et al. 2019 and Méndez-Ortega and Arauzo-Carod 2019b for Barcelona, and Murphy et al. 2015 for Dublin). There are numerous reasons for this, such as taking advantage of the capacity of bigger local consumption markets and the industrial diversity that benefits their work environment together with the possibility of networking activities and knowledge flows (Lorenzen and Frederiksen, 2008). Unfortunately, when we focus on Video Game firms, there is a scarcity of empirical contributions, since this is still a young industry that has recently exploded in terms of number of firms and employees, especially following the gaming expansion through mobile phones after the first iPhone was released (2007), and also thanks to the appearance of six-generation video consoles between 2006 and 2007.[28]

[28] Xbox360 (Microsoft), PlayStation3 (Sony) and Nintendo Wii (Nintendo).

When discussing city-specific characteristics that may influence location decisions, numerous papers anticipate growth in the number of high tech firms located in the central areas of big cities, a phenomenon that occurs mainly in western cities fuelled by agglomeration economies, social relations, high skill workers, institutions, talent and human synergies (see for example, Florida and Mellander, 2016; Hutton, 2004; Indergaard, 2013; van Oort and Atzema, 2004). Concretely, these central areas act as "territorial innovation systems" (Morgan, 2004) that favour the innovation activities carried out by firms. We assume that SVE firms agglomerate in a similar way as do creative firms, benefiting from both localization and urbanization economies (Lorenzen and Frederiksen, 2008): the first in terms of advantages provided by specialisation and the second in terms of advantages provided by industry diversity. In view of core location preferences of SVE firms, it seems that they benefit especially from interactions with firms belonging to quite different industries, although these linkages are expected to be stronger with (similar) creative firms. This agglomeration pattern enhances knowledge spillovers among firms (Florida, 2002) and provides additional incentives to locate close to other firms, reinforcing initial agglomeration processes.

There are also several papers that analyse the positive effect of "techno neighbourhoods" (Duvivier and Polèse, 2018) in terms of attraction of economic activity, economic growth and employment generation (Bagwell, 2008; Foord, 2013; Pratt, 2009; Rantisi and Leslie, 2010 and Viladecans-Marsal and Arauzo-Carod, 2012).[29] Some of these techno

[29] The term 'Techno Neighbourhood' refers to an area inside a city that has become attractive for digital economy activities (e.g., SVEs) that are carried out in workspaces that have been refurbished for this purpose.

neighbourhoods are related to urban policies aiming at generating clusters of such firms (*i.e.*, top-down strategies) and others to local clusters being generated by firms' decisions (*i.e.*, bottom-up strategies) (Fromhold-Eisebith and Eisebith, 2005).[30] Obviously, both processes are inter-related and causality may act in both directions (Yang et al. 2019), as some urban policies are driven by ex-ante decisions taken by firms and, conversely, some firms' strategies are triggered by urban policies favouring the creation of Video Game and Software firms' clusters. Urban policies might be targeted towards cluster formation, although there is still significant uncertainty and plentiful evidence of unsuccessful experiences (Braunerhjelm and Feldman, 2006) which may be explained in terms of a lack of connection of public projects with existent economic activity (Globerman et al., 2005). Since turnover rates are relatively high due to *i*) markets' dynamism and *ii*) low entry barriers (i.e., amount of capital needed to start a new firm is very low), and entries and exits thus regularly change the market composition, this point is extremely important for these industries.

In the light of these considerations, the experiences of Barcelona, Lyon and Hamburg are of interest, especially because their urban models differ in terms of core-periphery patterns and previous growth trends but, at the same time, they share some important urban renewal policies implemented in recent years. In general terms, the experiences of these cities depart from ambitious urban transformation projects (22@ in Barcelona, *Confluence* in Lyon and *HafenCity* in Hamburg) that aim to

[30] See Feldman et al. (2005) for a theoretical approach.

renew underdeveloped areas into hubs of high-tech activities, knowledge generation and economic transformation.[31]

Barcelona has seen important economic structural changes in recent years, especially after the Olympic Games of 1992 that was jointly responsible for the internationalisation and economic transformation of the city. In particular, the Poblenou district, traditionally a host for mature manufacture activities, radically changed policy with a view to moving from 19th century manufacturing activities to 21th century service activities. This strategy, driven by the local city council, was called 22@ and helped to transform a huge area of the city quite close to the urban core (Poblenou district). This highly successful policy "managed to attract new firms from knowledge economy and transform an industrial structure based on mature manufacturing activities to one based on high-tech services provided by both private and public institutions" (Viladecans-Marsal and Arauzo-Carod, 2012, p. 398).

Lyon shows some similarities with Barcelona as this city has an important manufacturing tradition deriving from previous centuries,[32] and has also some dissimilarities, as there are a several high-tech industries for which Lyon has an international reputation (pharmaceuticals and bio-engineering). Although Lyon was not specialised in computer-related activities, this industry was boosted by the creation and location of worldwide leader firms in computer games (*Infogrames* and *Electronic Arts*, respectively) and the *Confluence* quartier urban project, which is quite similar to 22@ in Barcelona, but with an

[31] See maps showing the urban transformation project and the CBD of each city in the Appendix C (Figure A3.1).

[32] Though some of most important firms had moved their headquarters to Paris (Moriset, 2003).

additional emphasis on urban renewal designed to improve quality of life and, specially, to implement sustainable urban criteria (Carpenter and Verhage, 2014).

Finally, Hamburg the most important German city for Software and Video Game firms, also plays a key role in this industry.[33] The *HafenCity* project for urban renewal of the former Hamburg port on the Elbe river, started in 2001 and has transformed a large part of the city (around 157 ha).[34] It is important to stress that *HafenCity* focuses not only on Software and Video Game industry, but also on retail firms, restaurants, residential buildings, hotels, entertainment activities, offices and a cruise ship terminal (Eleftheriou and Knieling, 2017). Although the expectation is that there will be important positive effects from these activities, it is also true that some time is needed for the full development of the *HafenCity* projects and to weigh their success.

Figure 3.1 shows the SVE yearly entries for each metropolitan area and the announcement data for each urban renewal project (2000 for Barcelona, 1999 for Lyon and 1997 for Hamburg). A closer look at the latter shows that announcements lead to entries in Lyon and Hamburg

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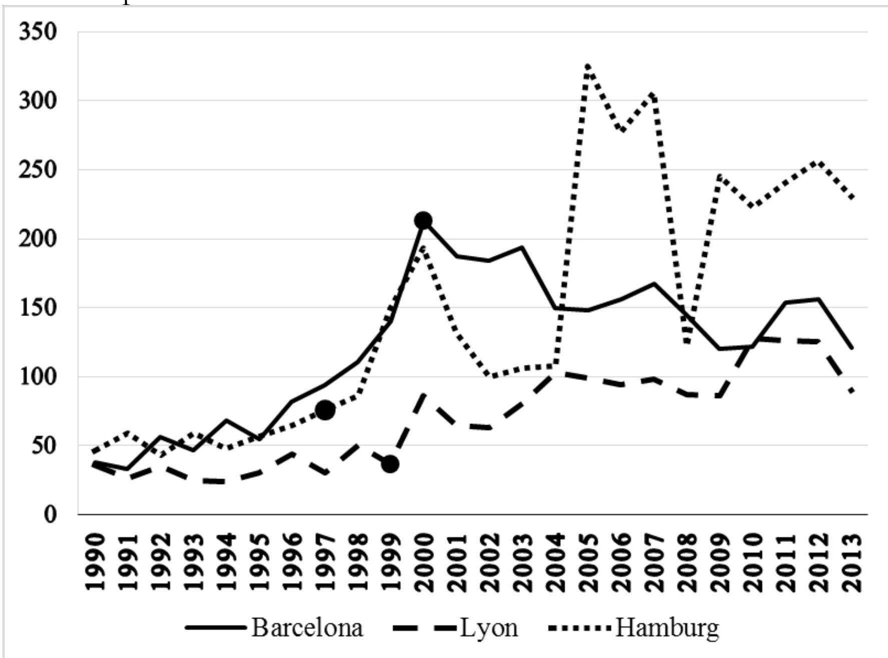
[33] Several well-known video game firms are already established in Hamburg, among others, Bytro Labs GmbH, Capcom Entertainment Germany GmbH, CrazyBunch UG, Exit Games GmbH, gamecity:Hamburg, gamigo AG, GRAEF Rechtsanwälte, InnoGames GmbH, Lost The Game Studios, Mooneye Studios, MSM Communications GmbH, Osmotic Studios, Pop Rocket Labs GmbH, Quinke Networks GmbH, RetroBrain R&D UG, Rocket Beans Entertainment GmbH, ROCKFISH Games GmbH, Square Enix GmbH, THREAKS GmbH, Tiny Roar UG, Tivola Publishing GmbH, toneworx GmbH, Valve GmbH, Warner Bros - Entertainment GmbH, and XYRALITY GmbH.

[34] *HafenCity* project is co-financed by private (€8.5 billion) and public investment (€2.4 billion).

in following years, whilst for the case of Barcelona the entry peak was the year that the project was announced.[35]

Figure 3.1 SVEs firm entries by year at Barcelona, Lyon and Hamburg at metropolitan level



Note: The black dots represent the announcement year of each urban renewal project (2000 for Barcelona, 1999 for Lyon and 1997 for Hamburg).

All three cities additionally have in common the basic locational requirements for high-tech firms (Baptista and Mendonça, 2010; Woodward et al., 2006) including accessibility (high-speed trains, airports and highways), availability of skilled labour (existence of reputed universities and post-graduated programs), high standards for

[35] We hypothesise that, since the 22@ Project in Barcelona took several years until it was formally launched, potential investors may have had most of relevant information of this Project in advance and, therefore, had anticipated their entry decisions some years before the official announcement.

quality of life (high-quality housing, cultural and recreational amenities), integration in a large and diversified market (European Union), and an existing network of firms in the same industry. These industry-specific assets increase the attractiveness of these locations as they lower operational costs (Malmberg and Maskell, 2002) and start-ups clusters' viability (Malmberg and Maskell, 2006).

3.3 Data and Methodology

3.3.1 Case studies selection and Data

The study areas of this chapter are Barcelona, Lyon and Hamburg and in their metropolitan areas. These cities have been selected according to *i*) their importance in terms of attractiveness of firms from these industries and *ii*) their similar institutional characteristics. Concretely, *i*) these cities have attracted a large number of Video Game and Software firms at the same time that local endogenous firms have emerged[36]; *ii*) according to recent data, the metropolitan area of Hamburg is the biggest one with 2.55 million inhabitants (2015), followed by Barcelona with 3.2 million (2016) and, further behind, by Lyon with 1.3 million (2014)[37]; *iii*) these cities play an important institutional role in their respective countries but they are not capitals, [38] which implies that,

[36] See Méndez-Ortega and Arauzo-Carod (2019b) for Barcelona, Moriset (2003) for Lyon, and Plum and Hassink (2014) for Hamburg.
[37] The relatively similar sizes of Barcelona, Hamburg and Lyon make them easily comparable.
[38] Barcelona is the second largest city in Spain and the capital of the region of Catalonia, Lyon is the third largest city in France and the capital of the region of Auvergne-Rhône-Alps, and Hamburg is the second largest city in Germany and one of the 16 German states.

although they benefit from being regional capitals, they do not have the advantages and disadvantages associated to country capitals.

The data used in this chapter comes from Orbis Database, a worldwide dataset that contains detailed data of more than 200 million firms around the world. [39] From this dataset, we obtain the stock of firms in 2015, as well as some variables at firm level (birth date, current address and activity code) in order to identify and classify each one of them into the relevant creative sector, as explained below.

In order to identify industries to be used in this analysis, we used the UNCTAD (2010). Classification. This classification includes both manufacturing and service creative industries and is broadly accepted by researchers (e.g., Boix and Lazzeretti 2012). Based on this classification, we obtain 17 categories (see Table 3.1).

[39] The Orbis dataset include several characteristics of firms, including year of entry, balance sheets, income, expenditure accounts, number of employees, industry, sales, assets, and georeferenced location (i.e., X-Y coordinates). Orbis collects data from the Mercantile Register of each country, where all limited liability companies and corporations are obliged by law to deposit their balance sheets. This is the most widely used dataset for any country in the world when georeferencing of firms is required and is provided by Bureau van Dijk.

Table 3.1 List of Creative industries classification

Nº	Creative industries	Acronym	NACE 2009 Codes
1	Advertising and related services	ADV	731
2	Architecture and engineering	AE	711
3	Art and antiques trade	ART	4779
4	Craft and Performing Arts	CPA	90
5	Cultural Tourism and Recreational Services	TRS	93
6	Publishing	ED	581
7	Fashion	FA	14, 1511, 152
8	Graphic arts	GA	181
9	Heritage, cultural sites and recreational services	HE	91
10	Creative research and development	IDC	721, 722
11	Jewellery, musical instruments, toys and games	JEW	321, 322, 324
12	Music and music studies	MU	182, 592
13	Photography	PHO	742
14	Radio and TV	RTV	601, 602
15	Software, Video Game and Editing Electronics	SVE	620, 582
16	Specialised services design	SSD	741
17	Video and film industries	VFI	591

Source: Own elaboration.

As mentioned in the previous sections of the chapter, we focus on the Metropolitan Areas (hereafter MA) of Barcelona, Lyon and Hamburg. The MA of Barcelona, located in Catalonia, north-eastern Spain, covers an area of 636 km^2 and includes 36 municipalities, the MA of Lyon (also called *Grand Lyon*) located in Rhône-Alpes, south-eastern France, covers an area of 515 km^2 and include 59 *communes* (municipalities), and finally the MA of Hamburg, which is the biggest metropolitan area subject to this study, covers an area of 2,087 km^2 and include 37 municipalities.[40]

The main reason to focus on these metropolitan areas is the large number of SVEs located in and around these cities and their metropolitan areas. Concretely the MA of Barcelona contains the 65.02% of the SVE's firms of all Catalonia, for the case of *Grand Lyon*, this contains the 85.26% of the SVE's firms of Rhône-Alpes, and finally the MA of Hamburg contains the 85.09% of the SVE's firms in the State of Scheleswig-Holstein, State of Hamburg and Lueneburg District.

Although these cities are clearly the economic and institutional hub of their MA, there are also some spatial heterogeneities at intra-city level that should be controlled. In order to do that, we will analyse location patterns at Barcelona, Lyon and Hamburg using intra-city administrative units (*i.e.*, districts).

[40] The cities of Barcelona, Lyon and Hamburg are divided in districts (10, 9 and 7 districts in each one respectively), which are comparable to the rest of municipalities of each MA.

Table 3.2 Number of Creative industries at City and Metropolitan Area level

		Barcelona			Lyon			Hamburg		
Nº	**CI Acronyms**	**City**	**MA**	**Total**	**City**	**MA**	**Total**	**City**	**MA**	**Total**
1	**ADV**	1924	367	2291	379	260	639	1479	226	1705
2	**AE**	2091	734	2825	1039	933	1972	1816	488	2304
3	**ART**	69	19	88	80	49	129	63	12	75
4	**CPA**	468	99	567	99	77	176	269	29	298
5	**TRS**	767	372	1139	119	138	257	1233	399	1632
6	**ED**	930	172	1102	125	65	190	514	85	599
7	**FA**	422	379	801	85	32	117	134	21	155
8	**GA**	869	675	1544	101	138	239	503	183	686
9	**HE**	41	10	51	0	2	2	58	10	68
10	**IDC**	225	93	318	97	88	185	272	67	339
11	**JEW**	141	42	183	93	38	131	82	17	99
12	**MU**	160	43	203	36	19	55	349	37	386
13	**PHO**	226	67	293	31	47	78	105	14	119
14	**RTV**	146	30	176	33	4	37	48	1	49
15	**SVE**	2346	801	3147	1046	864	1910	3810	746	4556
16	**SSD**	317	84	401	105	57	162	277	25	302
17	**VFI**	768	127	895	181	78	259	662	52	714
	Total	11910	4114	16024	3649	2889	6538	11674	2412	14086

Note: Creative industry acronyms can be found at Table 3.1. City refers to firms inside the city and MA refers to firms in the Metropolitan Area. Source: Own elaboration.

Table 3.2 shows the number of creative firms for each industry, sorted by city and MA. It is important to highlight the high number of SVEs in all the cities, this being the biggest creative sector in terms of number of firms for all the MA (except for Lyon, where Architecture and Engineering has 62 firms more than that of SVE). This fact highlights the importance of this industry inside the Creative industry for these metropolitan areas. Finally, regarding the firm distribution between

City-MA, we observe that although all the metro areas have the most part of their creative firms inside the main city, Barcelona and Hamburg have a higher share compared to Lyon (74% and 82% for Barcelona and Hamburg, and 56% for Lyon),[41] but this is easily explained in terms of size differences between central cities and the MA.

3.3.2 Spatial Methodology

In order to analyse the location patterns of SVE in the MA, we used the following techniques: Nearest Neighbour Index (NNI), Kernel densities, K-density Functions and Entropy Index. These indicators allow us to focus on different dimensions of location patterns of SVEs that are not brought out by any single one of them. Concretely, the Nearest Neighbour Index provides a broad overview of a firm's location and focuses on whether this follows a clustered or a random pattern. Kernel densities provide a graphical insight into this location. K-density Functions allow a more specific analysis of firms' agglomeration at a range of distances and the Entropy Index provides a broad picture of the predominant activities in a given area.

The NNI (Clark and Evans, 1954) analyses the spatial concentration of points (*e.g.*, firms) in a territory, and does not take into account firms being in different administrative units. The NNI is formulated as follows:

$$\boldsymbol{NNI = \frac{Observed\ Average\ distance}{Expected\ Average\ distance}}$$

[41] The lower share for Lyon is explained by the smaller surface of its capital both in absolute (48 Km^2 in front of 101 Km^2 of Barcelona and 755 Km^2 of Hamburg) and relative terms (the capital city represents only the 9% of the surface of the MA, a percentage much lower than that of Barcelona -15%- and Hamburg -36%-).

Where Observed Average Distance and Expected Average Distance are defined as:

$$Observed\ Average\ distance = \frac{\sum_{i=1}^{n} d_i}{n}$$

$$Expected\ Average\ distance = 0.5\sqrt{\frac{A}{n}}$$

and d_i is the distance between point *i* and its nearest neighbour, *n* is the number of neighbour links and *A* is the total area considered. Values of NNI can be interpreted as follows: values around 0 indicate a clustered pattern, values around 1 indicate a random distribution, and values higher than 2 indicate a uniform pattern (the maximum possible value is 2.15 for a hexagonal grid). NNI has been used previously (Rehák and Chovanec, 2012) to analyse the location patterns of creative industries in Slovakia.

Kernel density estimation is a non-parametric technique where the position of each firm is smoothed out from that firm into the surrounding area around it, defining a radius distance (in our case 250 and 100 meters for the MA and city level respectively) give an image of the firm distribution in a territory. The aggregation of the individually smoothed contribution of each point gives an overall picture of points' density, highlighting which locations have a high density of firms.

K-density functions (Duranton and Overman, 2005) gives the density of firms using a distance-based approach in order to determine the distribution of bilateral distances between firms from the same activity and/or different activity. We define an industry *S* with *n* firms, and then we compute a circle distance (*i.e.*, radius) between each pair of firms in that industry, obtaining $\boldsymbol{n(n-1)/2}$ bilateral distances for industry *S*. We denote $\boldsymbol{d_{ij}}$ as the distance in meters between firms *i* and *j*. Finally, the K-density function at any distance *d* is defined as follows:

$$\widehat{K}(d) = \frac{1}{n(n-1)h} \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} f(\frac{d - d_{ij}}{h})$$

where *h* is the optimal bandwidth, and *f* is a Gaussian kernel function, where all densities are calculated. We should mention that an employment-weighted version of the *K*-density exists, but here we do not use it.[42] Our K-density function is used in the intra- and inter-industry approaches, analysing the density of firms (bilateral firm distances) of an industry or the bilateral distance between a pair of industries comparing it to an average simulated value (of the whole creative firms) under the null hypothesis of same density value that the average simulated value for each distance. The K-density Function has been used in numerous papers in order to analyse the density of firms for each distance and how firms agglomerate (*i.e.* Behrens et al. 2016).

Finally, the Entropy Index (Theil, 1972) analyses whether a geographical unit is homogenous or diverse. Concretely, values close to 0 indicate that there is a predominant creative industry at the considered spatial unit (*e.g.*, a city district in this chapter), whilst values close to 1 indicate that there is no a predominant creative industry (i.e., industrial diversity is high). This index allows us to measure the co-location of SVE firms with other creative firms and test whether these firms tend to choose

[42] The employment-weighted version of the *K*-density function is not used because our research question, which focuses on the location and colocation of the Software and Video games industry inside metropolitan areas, only considers the firm's location, not its employment size.

locations with high level of diversity (Florida and Gates, 2003). This index is defined as follows:

$$E = \sum_{i=1}^{n} x_i \, log \frac{1}{x_i}$$

, where x_i refers to the share of the industry i in terms of number of firms, and n is the total number of industries at city level.

Used together, these techniques provide us with an overall spatial approach for different industries at several levels by measuring the SVE's concentration and location patterns (Kernel density and NNI) and its co-location (K-density function and Entropy Index) with other industries. Finally, it is important to mention that we are interested in both Software and Video Game firms, but as the Video Game industry is quite recent and empirical data is still scarce, we analysed both as a single industry.

3.4 The metropolitan location of the Software and Video Game industry: some results

3.4.1 Kernel density and Nearest Neighbour Index

Kernel density

Kernel density results indicate a general spatial concentration of creative firms at metropolitan and city levels and at city levels. The SVE industry, by contrast, tends to cluster into certain parts of the city centre, to be discussed below.

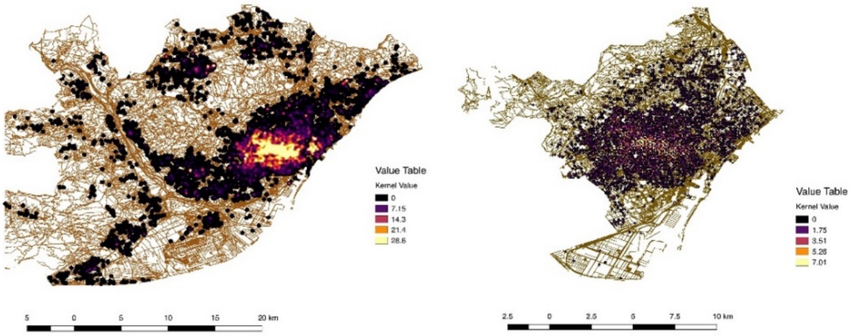
Figure 3.2 shows the spatial pattern of the aforementioned industries for the MA of Barcelona (hereafter MAB). It is important to note the existence of natural spatial discontinuities inside the MAB.[43] As shown on the map, there is a large concentration of creative industries inside Barcelona and the municipalities belonging to the MA but, if only SVEs are considered, then almost all of them locate in three areas of the city of Barcelona: Diagonal Avenue, and the Eixample and 22@ (Poblenou) districts. This represents a polycentric pattern in which there are very many firms in some central areas of the city while, at the same time, a similar number are located in high-tech neighbourhoods, a situation that is increasingly frequent in large western metropolitan areas, as shown for Barcelona (Méndez-Ortega and Arauzo-Carod, 2019b), Toronto, Montreal and Vancouver (Duvivier and Polèse, 2018; Duvivier et al., 2018) and Chicago (Yang et al., 2019).

[43] The city of Barcelona is bounded by the Mediterranean Sea in the east and by a wooded mountain area (Collserola) in the north-northwest between Barcelona and the North-Western municipalities.

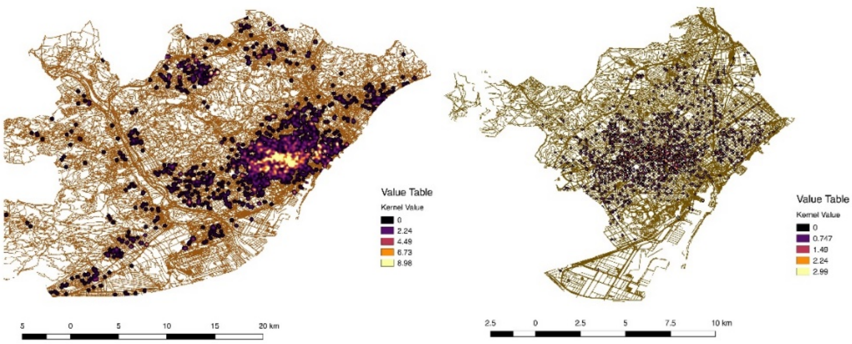
Figure 3.2 Kernel density for Barcelona at metropolitan and city levels

Metropolitan Area | City

All Creative firms



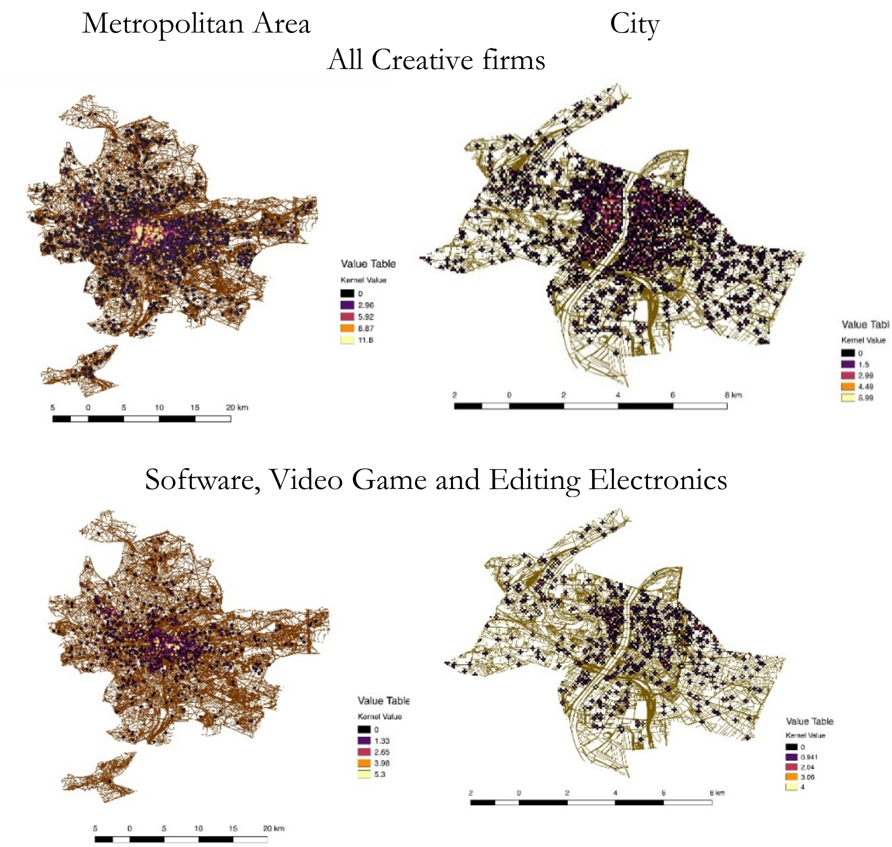
Software, Video Game and Editing Electronics



Note: The chosen bandwidth at metropolitan level is 250 meters and 100 at city level.
Source: Own elaboration.

Figure 3.3 shows the spatial pattern for the MA of Lyon (also called *Grand Lyon*). As in Barcelona, creative activities locate around all the MA, but they are concentrated in the city of Lyon, especially for SVEs. It is worth mentioning that SVEs do not agglomerate in the *Confluence* zone, inasmuch as these firms are located in the most central areas of the city (CBD). We assume that these firms may tend to be close to central areas in order to get sufficient accessibility to skilled workers, institutions, creativity and social relationships, creating places with a high variety of industries (Hutton, 2004). This may be similar to, for example, New York, where after the recent financial crisis, creative industries replaced finance as an economic driver inside the city (Indergaard, 2013) or to the cases of London, Vancouver and Singapore, where the collapse of Fordist production inside city centres produced a realignment of the metropolis core (Hutton, 2006).

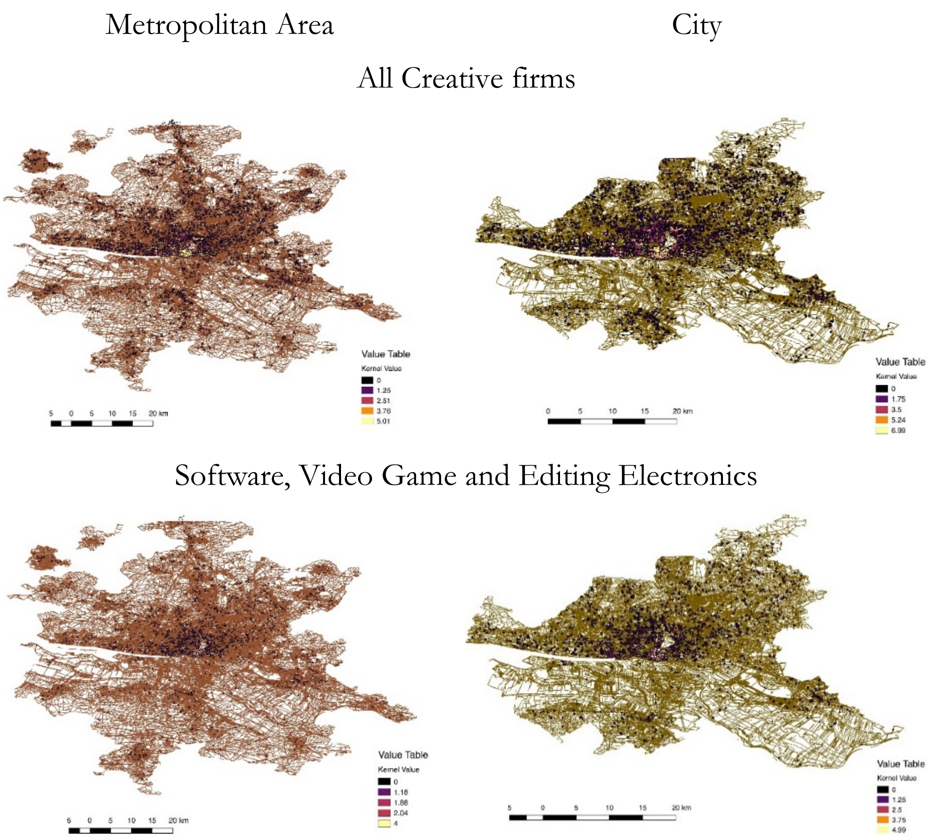
Figure 3.3 Kernel density for Lyon at metropolitan and city levels



Note: The chosen bandwidth at metropolitan level is 250 meters and 100 at city level.
Source: Own elaboration.

Finally, Figure 3.4 shows the spatial concentration for the MA of Hamburg. As in Barcelona and Lyon, whilst creative industries locate across the whole MA, SVE's firms show a slight concentration inside the city of Hamburg and, concretely, in the *HafenCity* quarter.

Figure 3.4 Kernel density for Hamburg at metropolitan and city level



Note: The chosen bandwidth at metropolitan level is 250 meters and 100 at city level. Source: Own elaboration.

To sum up these results, kernel densities suggest that there are three slightly different industry location patterns, one for each metropolitan area considered: *i*) in Barcelona there is a polycentric structure of SVEs as there are some subcentres in core areas and at the urban renewal area (22@); *ii*) in Lyon SVEs concentrate around city centre, but not in the urban renewal area (*Confluence*); and *iii*) in Hamburg, there is a clear concentration at the urban renewal area (*HafenCity*).

Nearest Neighbour Index

NNI values shown in Table 3.3 provide an overview of clustering of *i*) all Creative Industries and *ii*) SVE's industries (i.e., Software, Video Game and Editing Electronics) at Metropolitan area and city level altogether, and at Metropolitan area and City level separately.

Table 3.3 Nearest Neighbour Index from Creatives and Software and Video Game industry in Barcelona, Lyon and Hamburg (at City and Metropolitan Area level)

Barcelona	**Metropolitan Area + City**		**Metropolitan Area**		**City**	
	All creative	**SVE**	**All creative**	**SVE**	**All creative**	**SVE**
AOD	35.661	91.262	80.245	205.367	21.466	53.202
AED	140.815	311.768	277.891	617.867	77.782	136.516
NNI	0.253	0.293	0.289	0.332	0.276	0.390
N. Observations	16022	3146	4114	801	11908	2345
Z-Value	-180.827	-75.893	-87.273	-36.147	-151.148	-56.537
Lyon	**Metropolitan Area + City**		**Metropolitan Area**		**City**	
	All creative	**SVE**	**All creative**	**SVE**	**All creative**	**SVE**
AOD	62.760	125.563	112.659	209.067	25.529	60.851
AED	254.400	421.785	382.677	627.121	93.917	165.509
NNI	0.247	0.298	0.294	0.333	0.272	0.368
N. Observations	6537	1910	2889	864	3648	1046
Z-Value	-116.517	-58.718	-72.555	-37.486	-84.138	-39.124
Hamburg	**Metropolitan Area + City**		**Metropolitan Area**		**City**	
	All creative	**SVE**	**All creative**	**SVE**	**All creative**	**SVE**
AOD	88.646	174.253	220.666	460.218	62.262	122.404
AED	320.268	558.072	773.960	1379.154	238.434	411.866
NNI	0.277	0.312	0.285	0.334	0.261	0.297
N. Observations	14086	4556	2412	746	11674	3810
Z-Value	-164.207	-88.809	-67.167	-34.816	-152.725	-82.991

Note: AOD (Average Observed distance), AED (Average Expected Distance), NNI (Nearest Neighbour Index), SVE (Software, Video Game and Editing Electronics). All distances are in metres. Source: Own elaboration.

Location patterns of these spatial areas and industries have important specificities according to these two dimensions and, especially in terms of industries. NNI values are higher for SVE industries than for Creative ones (i.e., concentration is stronger for Creative industries), but for three metropolitan areas and cities they are quite similar. Concretely, Creative industries range from 0.285 to 0.294 at metropolitan level and from 0.261 and 0.276 at city level, whilst higher values for SVE range between 0.332 and 0.334 (metropolitan areas), and between 0.297 and 0.390 (cities).

In general terms, SVE industries have a similar concentration level across all metropolitan areas and cities (i.e., Barcelona, Lyon and Hamburg), but a further analysis allows us to identify two slightly different patterns. The first one corresponds to Barcelona and Lyon, where concentration is higher for their metropolitan areas than for the city capitals (i.e., higher concentration of SVE firms inside the whole metro area), whilst the second one corresponds to Hamburg, where the situation is exactly the opposite (i.e., higher concentration in the city, concretely in the *HafenCity* and surroundings). Obviously, the spatial scope of respective metropolitan areas matters as, for instance, quotients (e.g., in terms of population or jobs) between city capital and their metropolitan areas differ but, nevertheless, it is also clear that this result illustrates two different location patterns.

3.4.2 *Kd* Function

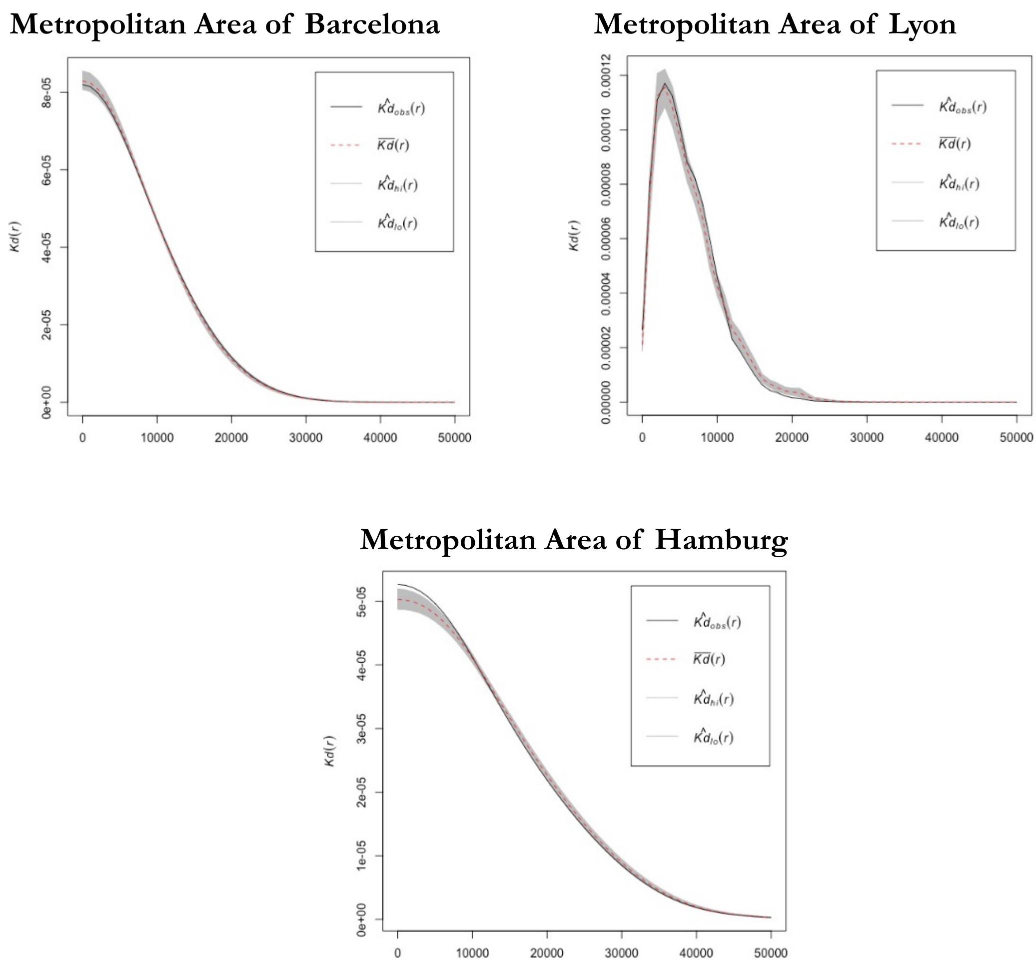
In next following graphs, we show the *Kd* function of the SVE for the Metropolitan Areas and the relationship between SVE's firms and Advertising and related services, Radio and TV, Graphic arts and Video and film industries firms.[44]

Intra-Industry Analysis

Figure 3.5 shows firm density for SVEs at city and metropolitan level. At first glance, it is observed that density of these industries differs across cities, presenting a similar pattern for Barcelona and Hamburg, and a completely different distribution for Lyon in the first tram of the radios (up to 5,000 meters). We suspect that in Barcelona and Hamburg business incubators and co-working spaces are relatively more important and, as these firms share the same venues, density is higher in the first tram, which is not observed in Lyon. SVE's firms have a similar concentration pattern almost identical to all creative sectors (dashed line), except for Hamburg, where the concentration of the SVE industry is higher than all the creative firms in the first tram of the radius (0-10,000 meters).

[44] All calculations use a 0.05 significance level, using 1000 simulations. The dashed line corresponds to the benchmark scenario, that is the density of all the economic activity (All Creative firms in our case) and the shaded area is the confidence interval.

Figure 3.5 *K*d Function for SVEs at metropolitan level



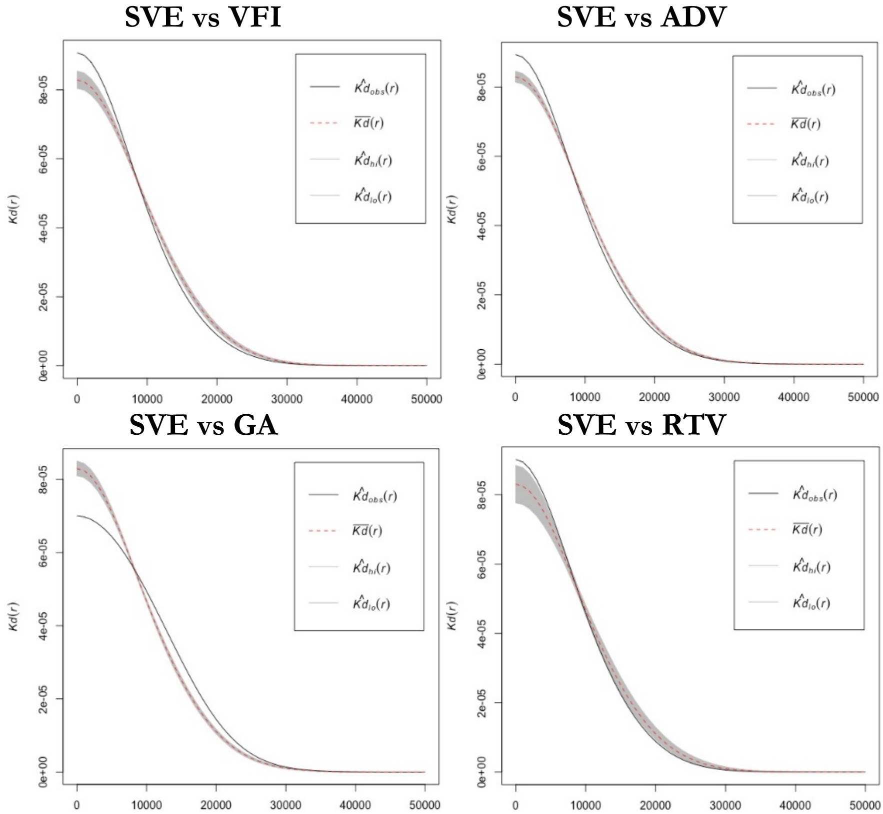
Horizontal axis units (r): meters. Source: Own elaboration. Note: The solid black curve is *Kd*. The dotted red curve is the simulated average of the whole creative activity, and the shaded area is the confidence interval under the null hypothesis of same density value for each distance.

Inter-Industry Analysis

In the following figures, the relationship between SVEs and other high-tech creative firms will be compared.

When the *K*-density between SVE vs VFI firms is compared, we observe that this pair of industries tends to be more concentrated than the whole creative sectors in a first tram of the radius for all the cities, indicating that they tend to locate close each other; the same happens with SVE vs ADV and SVE vs RTV, giving a *K*-density values higher than the whole creative sector in the first tram of the radius for all the cities. These interactions exist because they are related industries, in which part of their internal processes are intertwined and certain services are internally demanded among them (e.g., a radio firm will need services provided by a Software firm to solve malfunctions of their Software or to provide some technical assistance) and this concentration pattern generates networking opportunities (Coll-Martínez et al., 2019).

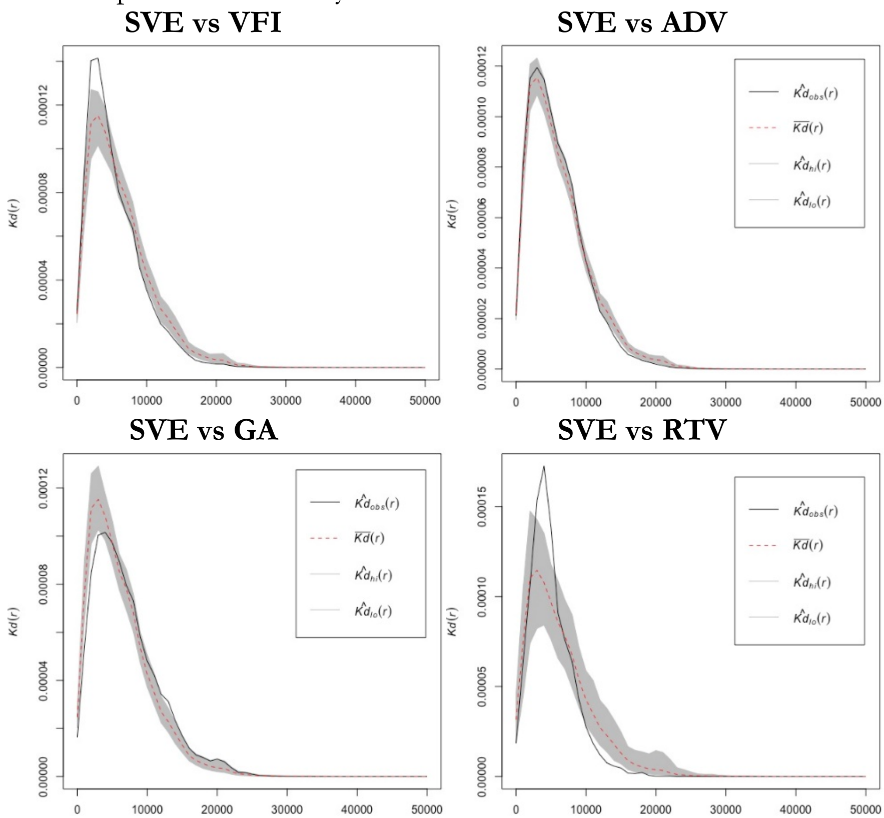
Figure 3.6 *Kd* Function of SVE vs. some Creative sectors for the Metropolitan Area of Barcelona



Horizontal axis units (r): meters. Source: Own elaboration.

In contrast, for the SVE vs GA case, we observe the opposite effect, since these sectors are dispersed compared to the whole creative sectors in a first tram of the radius for all the cities (i.e., agglomeration between SVE and GA firms is fewer than statistically expected at shorter distances). This is a quite surprising result that requires additional data in order to be fully understood.

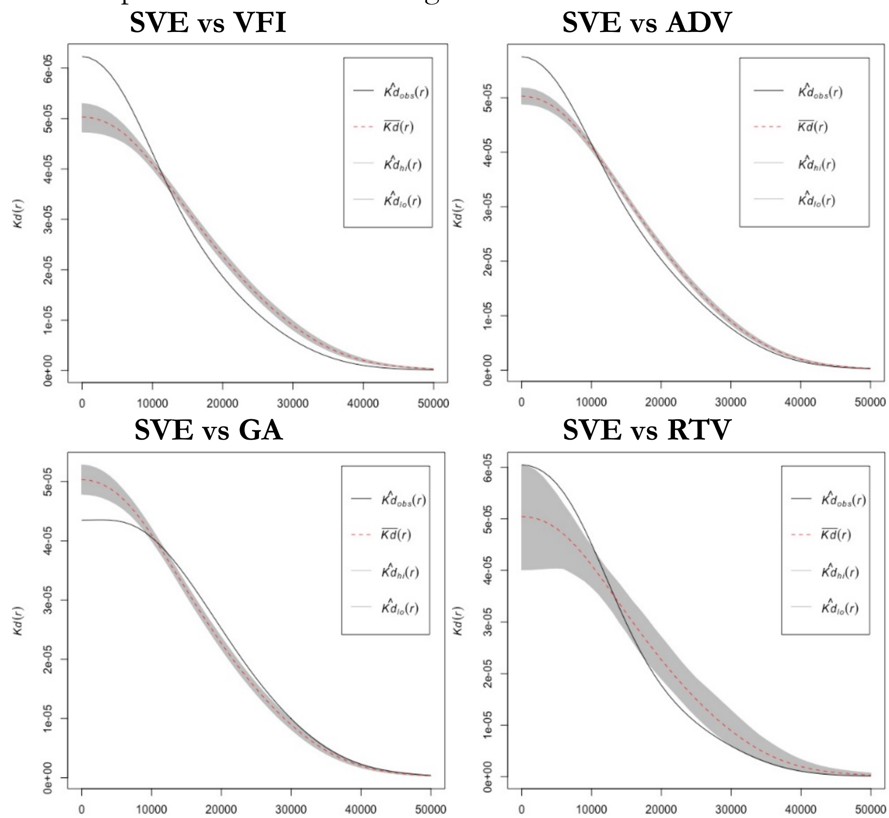
Figure 3.7 *Kd* Function of SVE vs. some Creative sectors for the Metropolitan Area of Lyon



Horizontal axis units (r): meters. Source: Own elaboration.

Summarizing, these results support the role of intra-urban agglomeration of the SVE industry in economic activity, especially with other high-tech firms. These results show that Software firms tend to locate close to core locations, at least in these cities. These results are in line with Duvivier and Polèse (2018), where it is shown that high tech firms tend to be located near other creative industries such as Arts-related occupations and Financial Institutions.

Figure 3.8 *Kd* Function of SVE vs. some Creative sectors for the Metropolitan Area of Hamburg



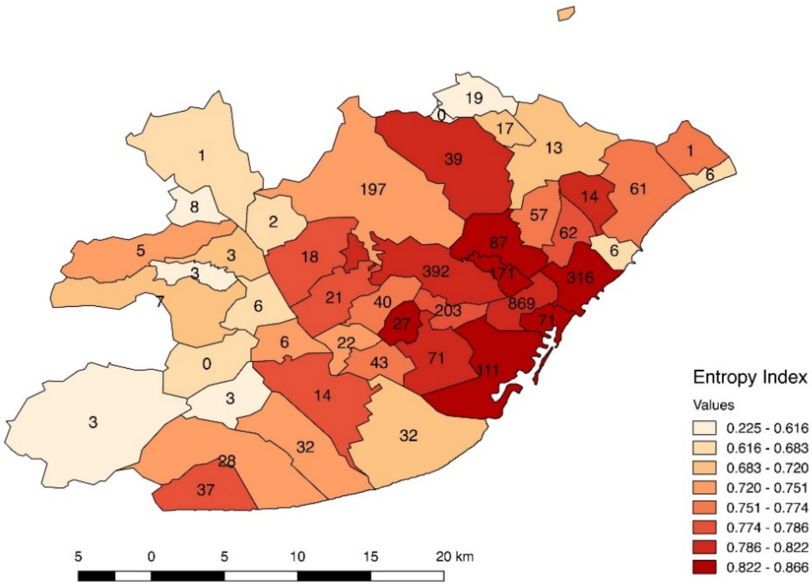
Horizontal axis units (r): meters. Source: Own elaboration.

3.4.3 Entropy analysis

Finally, Entropy Index (*E*) provides a different approach to spatial / industrial heterogeneity as it allows us to identify whether a spatial unit (*e.g.*, city district or municipality) is homogeneous or diverse. *E* ranges between 0 and 1, values close to 0 indicating that in this area there is a predominant industry, and values close to 1 indicating that the relative weights of each activity are similar. Figures 3.9, 3.10 and 3.11 show that, in general terms, the core areas of the three cities are those with higher entropy levels, i.e. those with a more diverse composition of activities, whereas peripheral areas tend to rely on a lower number of industries.

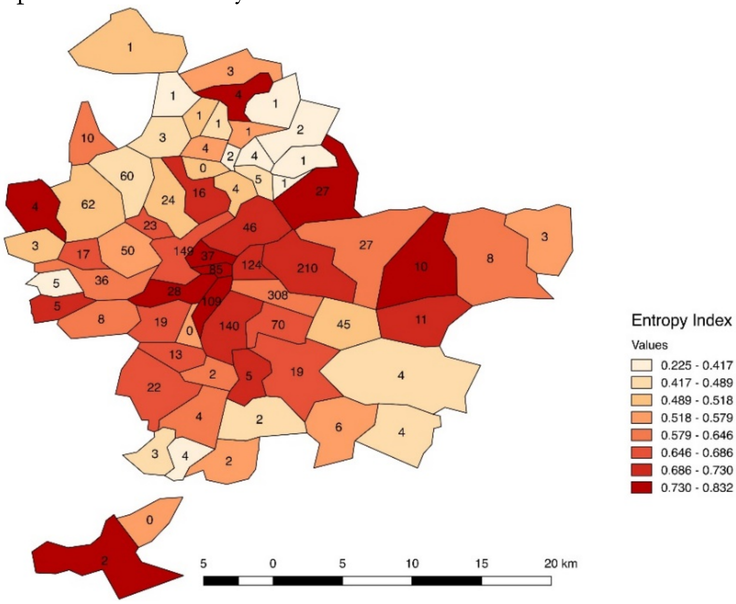
Nevertheless, there are some spatial discontinuities as there is no a single core in any of the three metropolitan areas in terms of firms' attraction.

Figure 3.9 Entropy Index and number of SVE firms by region in the Metropolitan Area of Barcelona



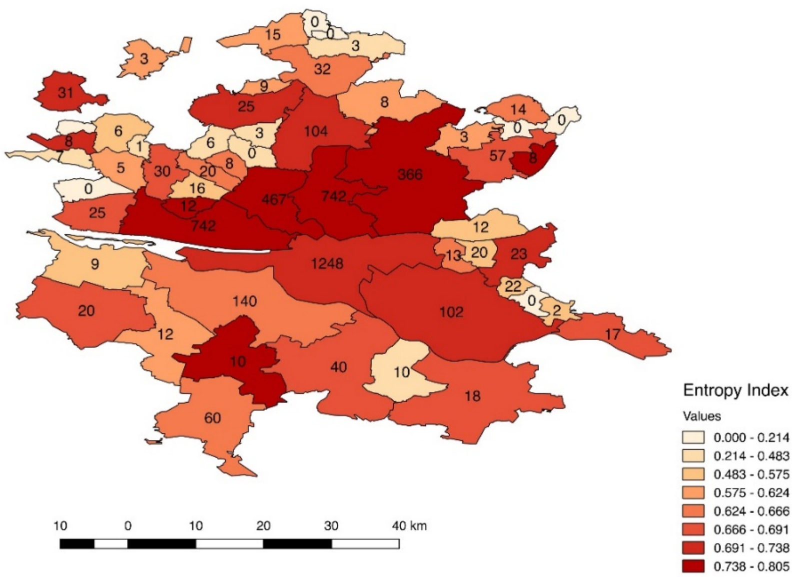
Note: Regions are municipalities and Barcelona city districts (10). Source: Own elaboration using Geo-Segregation Analyzer (Apparicio et al., 2014).

Figure 3.10 Entropy Index and number of SVE firms in the Metropolitan Area of Lyon



Note: Regions are municipalities and Lyon city districts (9). Source: Own elaboration using Geo-Segregation Analyzer (Apparicio et al., 2014).

Figure 3.11 Entropy Index and number of SVE firms in the Metropolitan Area of Hamburg



Note: Regions are municipalities and Hamburg city districts (7). Source: Own elaboration using Geo-Segregation Analyzer (Apparicio et al., 2014).

Additionally, in order to try to identify drivers of entropy, we have included number of firms at district / municipality level and, as expected, entropy is higher when there are a large number of firms. High tech firms tend to locate close to places where values such as tolerance, diversity and skilled human capital act as drivers of high technology entrepreneurship (Qian, 2013). Finally, these are places where creativity and multicultural environment provide an important stimulus to these firms in terms of innovation and growth (Florida and Gates, 2003). Previous creativity related features can be (partially) explained thanks to long-terms processes of talent attraction to CBDs but, in addition, it is noticeable that areas where core urban renewal projects were carried out (22@, *Confluence* and *HafenCity*) are, in general terms, among the ones that capture the highest number of SVEs (see Figures 3.9, 3.10 and 3.11). In this sense, we may differentiate Hamburg vs. Barcelona and Lyon cases since, for the former, the *HafenCity* district is quite close to the traditional CBD whilst, for the latter, there is a larger distance between the *Confluence* district and Lyon's CBD, and between 22@ district and Barcelona's CBD. This is an important point because it implies that, especially for Barcelona (and to a lesser extent for Hamburg and Lyon), the previously mentioned urban renewal projects have played a key role in reshaping the urban geography of SVEs, providing a more innovative environment that may increase the attractiveness of the area.

3.4.4 Summary

We analysed spatial patterns of SVE firms inside three MA of very different sizes and with different shares between core and periphery. Since we focused our results in terms of urban renewal projects of these areas (i.e., 22@ in Barcelona, *Confluence* in Lyon and *HafenCity* in Hamburg), it is important to notice that these projects were targeting different objectives, that their size differs, and that they are in different development stages. Our results show that firms' preferences vary across each one of the three cities and MA, and that these locational preferences cannot be explained in the same way by previous urban renewal projects. Location patterns in Barcelona are mainly polycentric and include both 22@ and traditional CBD whilst, for Lyon, firms locate mainly at monocentric CBD (but not in the *Confluence* district, perhaps because it is still in an early development stage). For Hamburg locational preferences are for *HafenCity*, which is inside the traditional CBD borders. Distances among SVE firms are also relevant, as they may reveal potential interactions. The concentration is stronger for Hamburg at *HafenCity*, whilst for Barcelona and Lyon concentration is higher for the whole MA. Finally, in terms of intra-industry and inter-industry analysis, the results are quite similar for all three cities, a logical pattern in view of the fact that the industries are the same and technologies are very similar across the three areas, so it is reasonable to expect to observe similar (if not the same) intra and inter-industry linkages.

3.5 Conclusions

In this chapter, we analysed whether location patterns and colocation strategies of SVE's firms share similar strategies across a sample of three European cities and metropolitan areas (Barcelona, Lyon and Hamburg) where these activities are of high importance. We focused on this industry because of its growing importance, its specificities as a high-tech creative industry, its strategic role in terms of city marketing and knowledge generation, and the potential higher European competitiveness in view of technological and human capital requirements SVE firms.

Our results strongly show the existence of intra-urban agglomeration in economic activity, especially when dealing with creative industries. More specifically, these results indicate that, although in Europe Software firms typically tend to locate close to core locations, there are (at least) three models that may be easily identified when comparing the location patterns of the SVE industry with those of all creative industries at city/metropolitan level: the first one consists of a strong concentrated pattern (Hamburg), the second one consists of an intermediate (polycentric) agglomeration pattern (Barcelona) and the third one consists of a relevant agglomeration (*intramuros*) pattern (Lyon). Obviously, these differences are triggered by specific local policies, urban structures, path dependence on previous spatial configuration of economic activity, and general city and metropolitan characteristics but, in general terms, they confirm that there is no a single agglomeration strategy to be followed by creative industries, which also implies that different policies may be provided according to the specificities of each metropolitan area. In this regard, one of main goals of policy makers should be the ex-ante identification of the agglomeration preferences of these industries for a given metropolitan area, in order to decide whether or not to increase existing agglomerations through, for instance, urban renewal projects aiming at attracting SVE firms. It seems that the success of urban renewal projects may be more important (in relative terms) for Barcelona and Lyon than for Hamburg. This conclusion, however, should to be treated with extreme caution because *HafenCity* being quite close to the traditional CBD in Hamburg, may explain it. Nevertheless, if we assume that the distance to CBD has this effect, then carrying out this type of urban renewal project at a sufficient distance to existent CBD, might help generate a polycentric structure instead of reinforcing the existing cores.

The previous considerations require analysing location patterns of SVEs before policy design and, perhaps amending and tailoring standard policy recipes not adapted to the specificities of each urban area. The purpose of entry-promoting policies is to attempt to provide firms with the desired economic environment and required services, which are shaped by previously explained intra–urban agglomeration patterns.

Overall, our results should be interpreted with care due to some potential limitations that we aim to solve in future research. Firstly, they correspond to a specific period of time and, therefore, may be biased due to different business cycle at city level.[45] Secondly, they refer to only three cities and metropolitan areas, and may include some city-specific effects not operating in other areas. Thirdly, they may be biased due to

[45] As a matter of example, in recent crisis contraction of economic activity started early in Barcelona and its duration has been longer than in Lyon and Hamburg.

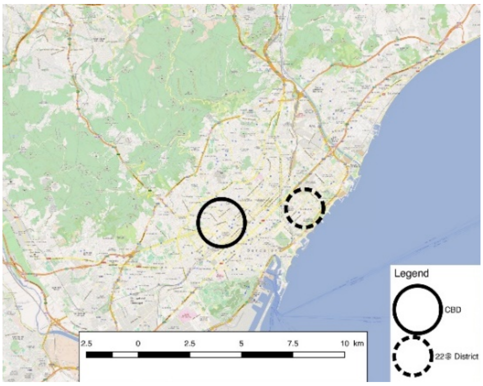
the criteria used in order to identify the metropolitan areas to be considered around each one of the three cities. Fourthly, they come from an overall analysis of firms from the SVE industry without taking into account whether differences in firms' size across the three metropolitan areas may also imply differences in location and agglomeration patterns. Further research should explore all these issues in order to provide more robust results by exploring alternative time spans, including other cities and metropolitan areas where these industries are relevant, testing alternative definitions of metropolitan areas, and differentiating firms by size.

Appendix C

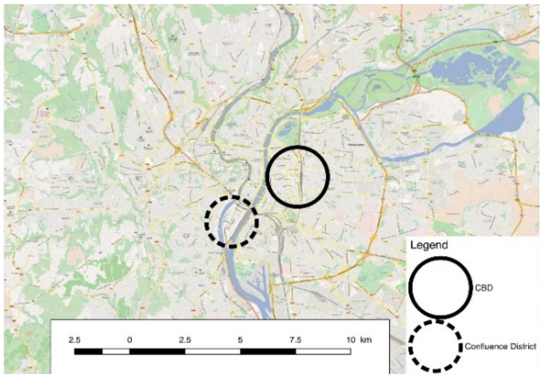
See Figure A3.1.

Figure A3.1 Central Business District and Urban Project location in each city

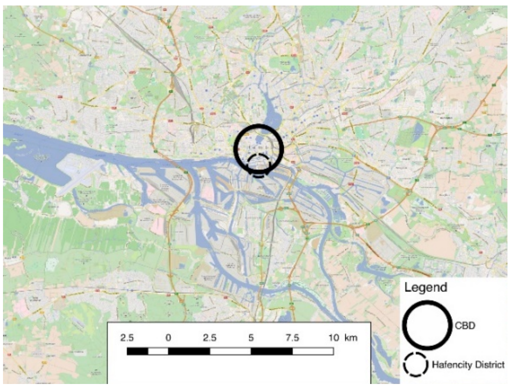
Barcelona



Lyon



Hamburg



Source: Own elaboration.

Chapter 4

Place the 'Candy' and 'Crush' it: Entry determinants of Software and Video Game firms in Barcelona[46]

4.1 Introduction

In recent decades, the Technological Revolution has changed the way in which people interrelate, communicate and work. This revolution has prompted the emergence and rise of high-tech industries, considered the key drivers behind economic growth in developed countries due to their capacity for knowledge generation, creativity and innovation (Berger and Frey, 2016). One of the most important high-tech industries, which has a huge impact on the economy and economic growth and which is analysed in this study, is the Software and Video Game industry (SVE hereafter).

There are many ways to define Software but, in general terms, Software is a set of instructions, information and/or programs that are given to a computer to do specific tasks. So, the SVE industry covers a wide variety of firms: for example, Software development firms, Software management firms and Video Game firms (companies that combine

[46] 'Candy Crush' is a puzzle Video Game released by King (Video Game firm located in Barcelona). In the game, players complete levels by swapping colored pieces of candy on a game board to make a match of three or more of the same color and then they crush. The player scores points for these matches when candies crush.

Software development with a more creative component in order to create electronic entertainment games).

The impact of this industry in the current world economy is huge and it is constantly growing. Indeed, in 2014, the total contribution of this industry in terms of GDP to the economy of the European Union (EU) was more than 900 billion euros (7.9% of the EU28 GDP). In the same year, the industry generated more than 11.6 million jobs (5.3% of the EU28 jobs), of which 3.1 million were direct jobs. The wages in this industry are considerably higher than in other industries (e.g. the EU average wage for the Software industry is 34% higher than the EU average wage and 80% higher than the average wage in the services sector). This is because it is a highly qualified industry with highly skilled workers. In Spain, the total contribution of this industry to the GDP is more than 35,800 million euros (3.4% of the Spanish GDP) and more than 624 thousand jobs are SVE-industry related (219 thousand direct and 405 thousand indirect jobs) (BSA & The Economist Intelligence Unit, 2016). The sector has 360 thousand employees (whose average salary is over 30 thousand euros per year) and adds 30 billion euros of gross output to the Spanish economy (INE, 2013). However, the impact of the SVE industry is greater and more far reaching than economic indicators suggest, since its technology is a part of almost all economic sectors.

The SVE industry belongs to the Information and Communication Technologies industry (commonly known as ICT) and is regarded as a creative industry (Boix and Lazzeretti, 2012). Creative industries are economic activities that are closely linked to the generation of knowledge (i.e. advertising, crafts, fashion, film and music, among others) (Howkins, 2001). In these industries, human capital plays a crucial role, since it is the main input and can make the difference between the success and failure of economic activity. The location patterns of creative firms have been an interesting topic for researchers because creative firms are an important factor in local economic growth and development (Coll-Martínez et al., 2019). Also, the emergence of creative firms improves the competitiveness and diversity of local economies (De Propris, 2013).

The SVE industry is mainly located in urban areas, since there are good infrastructures, good accessibility to amenities and a high level of human capital (i.e. more educated people). Therefore, these are environments in which information and contacts between firms flows easily. Due to the economic importance and economic growth of the industry, a large number of cities, as a strategy to attract this type of firms, have developed urban projects aiming to create technological districts (e.g. Méndez-Ortega and Arauzo-Carod,2019a, which discusses the 22@ district in Barcelona, the *HafenCity* district in Hamburg and the *Confluence* district in Lyon).

Most previous empirical research into location determinants of high-tech firms has been done at country and/or regional level, even though this industry is purely urban. For this reason, this chapter contributes to the literature by providing an empirical study that analyses the location determinants of the SVE industry at the urban level, and deals with factors that have not been taken into account, or have not been analysed together on this scale (i.e. traditional factors such as agglomeration economies, human capital and amenities; social factors such as cultural and creative diversity; and crime factors, widely used in US studies but not in European studies).

Our main results show that at the city level, SVE firms tend to choose locations with a high diversity of creative firms, social amenities and high-tech amenities (*e.g.* the 22@ district in Barcelona). They also show the importance of agglomeration economies: SVE firms choose locations with a large number of well-established SVE firms, which shows the importance of spatial spillovers for this type of firm.

The rest of the chapter is organized as follows. Section 2 reviews the theoretical and empirical literature about the location determinants of SVE firms. Section 3 describes the data and the econometric methodology. Section 4 introduces and discusses the main results. And finally section 5 presents the main conclusions.

4.2 Location of Software and Video Game firms at the intra-urban scale

Firm location determinants have been one of the most studied topics in Urban and Regional Economics since the seminal work by Marshall (1890), which explained the location of new plants in industrial districts. Since then and to this day, firms' location decisions have been both an important topic for academics from a variety of areas and a great topic of interest for firms, since optimal location means greater profit, market accessibility and, in general, can mark the difference between success and business failure.[47]

Throughout the 20th century, most research into industrial location, agglomeration and industrial patterns focused on theoretical issues, and the few empirical studies, there were mainly dealt with manufacturing industries. For a few years now, empirical studies on industrial location have been changing from manufacturing industries to high-tech industries, due to their interest for entrepreneurship and economic growth (Gilbert, 2017). Even greater interest is shown in the location and clustering of the Information and Communication Technology industries, which has been analysed by large numbers of researchers in recent years because of their impact on every economic industry (Fernhaber et al., 2008; Giblin, 2011).

Most of these studies focused on location at the regional or country level, but less is known about the location determinants of these industries at the urban level, even though these industries are only located in urban contexts. The novel work by Jacobs (1969) and Lucas (1988) gave rise to urban theory, which proved that the greater economic performance of cities is due to the huge density of human capital. Hence, this type of industry has boosted the growth of large cities, since it has been observed that cities where there is a high endowment of human capital grow substantially more than those where this endowment is more restricted (Berger and Frey, 2016).

[47] An extensive empirical review on industrial location can be found in Arauzo-Carod et al., (2010).

4.2.1. Location determinants of Software and Video Game firms

The spatial concentration of high-tech activities is an established fact in almost every developed city around the world. There is a lengthy body of literature which explains the nature and extent of urban agglomeration economies (for a survey, see Duranton and Puga, 2004; Rosenthal and Strange, 2004).

The intra-metropolitan location decision is essentially based on cost minimization and not firms' profit, since for high-tech activities consumer demand for output is assumed not to vary within intra-metropolitan locations (Gómez-Antonio and Sweeney, 2018). So, the cost function (*C*) for a firm selecting a location has been represented in the literature as the function[48]:

$$C = F(AE, G, HC, t, LP, S)$$

where *AE* are the agglomeration economies, *G* are the public services in the area (e.g. transport services, Wi-Fi public services, public centres, urban renewal areas made by public initiative, among others), *HC* is the human capital or skilled labour in the area, *t* and *LP* are the effective tax rate and land price and *S* is a vector of general site characteristics (i.e. covariates such as the presence of technology parks, universities, creative diversity, crime in the area and other site characteristics that affect high-tech firms' location). Numerous empirical studies have shown the impact of these variables on firms' location decisions (see below).

[48] These covariates and specifications for high-tech firms' location are in line with the literature (see Brülhart et al., 2012 and Gómez-Antonio and Sweeney, 2018).

Several empirical studies have shown the positive impact of agglomeration economies as a location determinant for high-tech industries at the regional/country level (e.g. Audretsch and Lehmann, 2005 and Kinne and Resch, 2017, for the case of Germany or Frenkel, 2012, for the case of Israel, among others) or the metropolitan level (e.g. Arauzo-Carod and Viladecans-Marsal, 2009, for Barcelona, and Hackler, 2003, for a set of US metropolitan areas). The main reason that leads these firms to locate close to each other is to create networks, input and output linkages, and to improve product and process innovation (Lyons, 1995). This attraction seems to be more intense with such creative sectors as the video and film industries, advertising or radio and TV firms, because their activities are similar and connected (Méndez-Ortega and Arauzo-Carod, 2019a).

An important location determinant for SVE firms is the availability of good amenities. A city with a good allocation of high-tech amenities is a city that attracts a large number of SVE firms. One of the amenities that has been successful in attracting knowledge-based and high-tech firms are "techno-neighbourhoods" (Duvivier and Polèse, 2018). These are places inside the city with a large number of resources for firms that facilitate interaction between them. One example is the success of the 22@ district in Barcelona, an urban renewal project promoted in Barcelona that aimed to attract high-tech firms (Viladecans-Marsal and Arauzo-Carod, 2012). Also worth noting are amenities such as Wi-Fi hotspots inside the city, since they can be a proxy of virtual vitality and, therefore, an indicator of urban vitality (Kim, 2018), contributing to the creation environments that generate knowledge.

Another significant factor for the location of SVE firms is cultural and creative diversity, since high-tech firms make location decisions based on where talented people are located. As Florida and Gates (2003) suggested, there is a connection between the level of tolerance of a metropolitan area, in conjunction with its ethnic, social and cultural diversity, and the attractiveness of the area for talented people in high-tech firms, which generates the emergence of this type of firm as an indicator of a metropolitan area's high-technology success. So, as empirical evidence suggests, places with considerable creative diversity and a good social environment (i.e. tolerance and talent) are places where high-tech and knowledge-intensive firms will be located (Yamamura and Goto, 2018; Zandiatashbar and Hamidi, 2018).

As mentioned above, human capital is a basic and strategic input for SVE firms. For this reason, the role of higher education providers (i.e. universities, research centres and tertiary education institutions) in the training of human capital is fundamental. Cities that are active in education tend to have a large share of highly educated workers (Abel and Deitz, 2012). These institutions have an impact not only on human capital formation, but also on the generation of knowledge, R&D activities, innovation processes and externalities. This explains the location of new firms close to these institutions, since university spillovers are important for high-tech firms (Acosta et al., 2011) and R&D firms in general (Abramovsky and Simpson, 2011).

Other significant factors are the rental prices and taxes. Generally, firms will choose locations where prices and taxes are lower. Some empirical studies show that prices and taxes have a negative effect on the location of high-tech firms (e.g. Acosta et al., 2011 and Wang et al., 2017; among others). Nevertheless, in a city, taxes are constant and the effect of land price tends to be captured by other variables, as Figueiredo et al. (2002) suggested (*e.g.* agglomeration economies).

Finally, crime is a determinant to be taken into account, since it is proven that it affects the location of high-tech activity (Goetz and Rupasingha, 2002 and Hackler, 2003). Unfortunately, this variable is used more often in US studies than in European studies, because in Europe there is not such an established tradition of collecting crime data.

Thus, now that we have seen the main location determinants of SVE firms, we present a set of empirical studies which discuss what determines a high-tech or knowledge base firm's location choices (see Table 4.1).

Table 4.1 Summary of recent location studies on high-tech, knowledge-based and/or SVE firms

Studies	*LAE*	*HTA*	*CCD*	*HC*	*LPT*	*C*
Abramovsky and Simpson (2011)	X	X		X		
Acosta et al. (2011)	X	X		X	X	
Audretsch and Lehmann (2005)	X	X		X		
Audretsch and Keilbach (2004)		X		X		
Chatman and Noland (2011)	X	X		X		
Marra et al. (2017)	X					
Florida and Mellander (2016)	X	X	X	X		
Florida and Mellander (2009)				X	X	
Goetz and Rupasingha (2002)	X			X	X	X
Hackler (2003)	X	X		X		X
Kinne and Resch (2017)	X	X		X	X	X
Li and Zhu (2017)	X	X		X		
Li et al. (2016)	X			X	X	
Méndez-Ortega and Arauzo-Carod (2019b)	X	X	X			
Viladecans-Marsal and Arauzo-Carod (2012)	X	X		X		
Wang et al. (2017)	X	X			X	
Wood and Dovey (2015)	X		X	X	X	
Woodward et al. (2006)	X	X		X	X	
Zandiatashbar and Hamidi (2018)	X	X	X	X		

Source: Own elaboration. Note: *LAE* (Localization and Agglomeration Economies), *HTA* (High-Tech Amenities), *CCD* (Cultural and Creative Diversity), *HC* (Human Capital), *LPT* (Land Price and Tax) and *C* (Crime).

Each of the studies analyses some of the determinants discussed above. However, none of them analyse them all at the same time and at the urban scale. Therefore, this chapter analyses all these determinants as a whole, and gives a more accurate vision of what determines the location of SVE firms within the city. Along these lines, at the urban level we expect the following:

Hypothesis 1: *The impact of High-tech amenities, Cultural and Creative Diversity and Human Capital will have a positive impact on SVE firm entries while these impacts will be different across types of entry (i.e. Creative and All entries). The impact of High-tech amenities and Human Capital will be higher for SVE firm entries than for Creative and All firm entries.*

Amenities are expected to be important for this industry (Li and Zhu, 2017; Woodward et al., 2006), as is cultural diversity (Florida and Gates, 2003) and this impact will depend on the type of firm (SVE firms, Creative firms and All firms). Also, we expect that:

Hypothesis 2: *The impact of Agglomeration economies, High-tech amenities, Human Capital, Creative and Cultural Diversity and Crime on SVE firm entries will go beyond neighbourhood borders.*

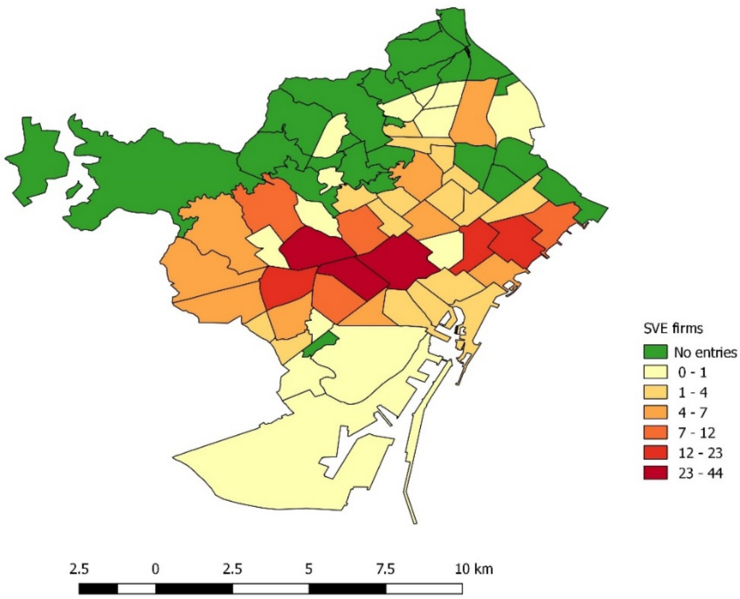
Space for industrial location is one of the most important issues. Empirical evidence has shown that the location of new economic activity is connected to space (see Liviano and Arauzo-Carod, 2012, for an extensive discussion on the importance of space for the location of new economic activity). This hypothesis is raised because firm location and space has been subject to a considerable amount of analysis at country, regional and municipality level but not at the urban level, which we expect to have an impact on SVE firm entries.

4.3 Data and methodology

4.3.1. Study area and datasets

This empirical analysis focuses on the location of the Software and Video Games firms in the city of Barcelona at the neighbourhood level. This city is the second biggest city in Spain in terms of population (1.6 million inhabitants in 2016) and has a surface area of 101.9 km^2.[49] Due to sea and mountain restrictions, it is a densely populated city (more than 15,800 inhabitants per km^2). The city is divided into 10 districts and 73 neighbourhoods (see Figure 4.1).

Figure 4.1 Number of SVE firms entries (2011-2013) in the city of Barcelona by neighbourhoods (73)



Source: Own elaboration.

[49] Our area of study is the city of Barcelona and not its metropolitan area (which includes 35 municipalities). This is because there is no information for some municipalities so an analysis at the metropolitan scale cannot be made. Nevertheless, the city of Barcelona accounts approximately for 80% of SVE firms in the metropolitan area.

To carry out this analysis, we used firm and city characteristic variables. The data on the firms from Barcelona city and their basic information (i.e. location and year of establishment) are taken from SABI[50] (Sistema de Análisis de Balances Ibéricos, INFORMA). The data on the neighbourhoods is mainly taken from the Barcelona City Council's open data service (known as Open Data BCN). This database provides social, economic and demographic information about the city for several aggregation levels (city, district, neighbourhood and census level).

To identify the SVE firms and other creative activities, we used the classification by UNCTAD (2010). This classification includes all creative industries (both manufacturing and service creative industries) and is widely accepted by researchers (see Boix and Lazzeretti, 2012 and Méndez-Ortega and Arauzo-Carod, 2019b).[51] Therefore, we include 17 creative sectors (of which only SVE, Advertising, Video and film and Radio and TV firms will be treated individually, and the rest jointly)[52].

[50] SABI is a database of firms that collects information from the Spanish Mercantile Register, where all limited liability companies and corporations are obliged by law to deposit their balance sheets. Due to its coverage SABI is the most widely used database in Spain when firm georeferenciation is required.
[51] A definition of each creative industry and their respective NACE codes can be found in the Appendix D (Table A4.1)
[52] These industries were selected in accordance with Méndez-Ortega and Arauzo-Carod (2019a) and are related to the SVE industry through their processes.

Table 4.2 Descriptive statistics of covariates by neighbourhood

Acronym	Description	Expected effect	Source	Mean	Standard Deviation	Max	Min
	Agglomeration economies						
Loc10(SVE)	Stock of SVE firms in 2010	+	SABI	23.232	44.587	283	0
Loc10(Cre)	Stock of Creative firms in 2010	+	SABI	106.689	187.007	1075	0
Loc10 (all)	Stock of all firms in 2010	+	SABI	866.698	1599.765	9552	8
Aggl10	Stock of VFI, ADV and RTV firms in 2010	+	SABI	31.041	64.203	378	0
	High-tech Amenities						
Wifi	Nº of Wi-Fi Hotspots in the neighbourhood	+	OD-BCN	8.096	10.443	56	0
CTP	Nº of Scientific and Technology parks	?	OE	0.110	0.315	1	0
Dist22	Dummy var. (value 1 whether the neighbourhood belongs to 22@)	+	OE	0.0548	0.229	1	0
	Diversity						
Entropy*	Entropy index of Creative firms in 2010	+	OE	0.675	0.202	0.880	0
Markets	Nº of Craft street Markets in 2010	?	OD-BCN	1.342	1.988	12	0
	Human Capital						
University	Nº of universities (faculties) in 2010	+	OE	0.808	1.838	11	0
Edu10	Proportion of high educated population in 2010	+	OD-BCN	0.213	0.121	0.497	0.022
Popd10	Population density (pop. per residential surface) in 2010	+	OD-BCN	692.962	305.875	1504	30.054
	Crime						
PolRat	Nº of police incidents per 1000 hab	-	OD-BCN	2.334	2.488	14.90	0.0650

Note: OE (Own elaboration), OD-BCN (Open Data Barcelona). (*) This index is an indicator of equality (Theil, 1972) which ranges between 0 and 1 to detect whether a spatial unit is homogeneous or diverse. In our case we apply this index to the diversity of creative firms in the area (i.e. neighbourhood).

Table 4.2 shows some descriptive statistics of the variables used in this chapter. Selected variables are in line with the economic theory of location and with the empirical evidence of high-tech firm location determinants discussed in the previous section (Hackler, 2003; Kinne and Resch, 2017).

4.3.2. Methodology

Model specification

This empirical analysis focuses on Software and Video Games firms in the city of Barcelona. Using the previous theoretical and empirical review on firm location, we estimate the number of new firms in a neighbourhood as a function of specific neighbourhood characteristics:

$$\begin{aligned} Firm\ entries_{i(2011-2013)} &= \beta_0 + \beta_{1n} AE_{in} + \beta_{2k} HTA_{ik} + \beta_{3j} CCD_{ij} \\ &+ \beta_{4h} HC_{ih} + \beta_5 Crime_i + \mu_i \end{aligned}$$

where *Firm entries*$_{i(2011-2013)}$ is the number of firms located in neighbourhood i between 2011 and 2013, AE_{in} are Agglomeration economies in neighbourhood i where (n = 1,…,N) is the set of these variables, HTA_{ik} are High-tech amenities in neighbourhood i where (k = 1,…,K) is the set of these variables, CCD_{ij} is Creative and Cultural diversity in neighbourhood i where (j = 1,…,J) is the set of these variables, HC_{ih} is Human Capital in neighbourhood i where (h = 1,…,H) is the set of these variables and $Crime_i$ is the number of police incidents in neighbourhood i in 2010.[53]

[53] Land costs are included in the neoclassical economic theory of location, but we did not include them in the empirical model, since taxes are the same across all neighbourhoods and the land price effect is captured by other variables such as

To make a general comparison of firm entries, three different dependent variables were used (SVE firm entries, Creative firm entries and All firm entries).[54] This made it possible to check differences between entry determinants between industries and it gave more accurate information about the results, since the impact of selected covariates can be compared across industries.

Model selection

To ensure that the group of covariates would properly explain SVE firm location decisions, we included the variance inflation factor (VIF) and correlation diagnostics in our model. VIF provides an index of how much higher the variance is when covariates are correlated than when they are uncorrelated. There is a multicollinearity problem whenever this value is higher than 10. For our subsamples, all VIF values were below 3, so we rejected the possibility of a multicollinearity problem. Furthermore, we tested the covariate correlations and most potentially correlated variables had values around 0.[55]

The number of firm entries in an area is most commonly modelled with Count Data models (CDM) (Arauzo-Carod et al., 2010). CDMs represent the number of occurrences of an event within an area in a fixed period. These models include the Negative Binomial model (NBM), the Poisson model (PM), the Zero-Inflated Binomial Model (ZIBM) and the Zero-Inflated Poisson Model (ZIPM). To determine

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population density or agglomeration economies (Figueiredo et al., 2002). To test this, we found a positive and statistically significant effect of population density and education on rent prices in Barcelona (Table A4.2).

[54] The variable Creative firm entries does not include SVE firm entries and the variable All firm entries does not include Creative firm entries. We tried including them, but the results did not change (see Robustness checks section).

[55] See correlation table in the Appendix D (Table A4.3).

which models fitted our estimation, we used the Akaike information criterion (AIC), the Bayesian information criterion (BIC) and the Vuong test as Cameron and Trivedi (2013) suggest.[56]

Table 4.3 Descriptive statistics of dependent variables

Acronym	Description	Mean	Standard deviation	Max	Min	% of Zeros
Sve_ent	SVE firm entries 2011-2013	4.479	8.386	44	0	32.87
Cre_ent	Creative firm entries 2011-2013	16.082	29.254	167	0	19.17
All_ent	All firm entries 2011-2013	92.671	175.980	1127	0	2.73

Source: Own elaboration.

Descriptive statistics of the dependent variables (see Table 4.3) suggested that there was not a problem of overdispersion or zero inflation. To test which model fitted best for each situation, we estimated a baseline specification for each case using CDM and applied the aforementioned selection tests (Table 4.4). These results determined that the PM performed best for SVE firm entry specification and NBM performed best for Creative and All firm entry specifications. Moreover, the Vuong test was not statistically significant, so we rejected zero-inflated models.

[56] AIC and BIC are standard measures to test which model best fits the data. The model with the lowest AIC and BIC value is preferred to the rest of the models. The Vuong test (Vuong, 1989) tests the significance of a zero-inflated model compared to a non-zero inflated model in terms of a significant difference from zero in the overdispersion parameter. So, a positive and statistically significant value will indicate that a zero-inflated model is preferred.

Table 4.4 Selection model's tests

	AIC	BIC	Vuong Test
Model 1 (SVE firms)			
Poisson	286.349	320.706	-
Negative binomial	302.665	334.732	-
Zero-inflated Poisson	290.021	328.959	0.526
Zero-inflated negative binomial	304.513	341.161	0.205
Model 2 (Creative firms)			
Poisson	415.352	447.136	-
Negative binomial	392.779	427.136	-
Zero-inflated Poisson	414.131	450.778	0.731
Zero-inflated negative binomial	396.779	435.717	-0.149
Model 3 (All firms)			
Poisson	1188.898	1220.964	-
Negative binomial	663.867	698.224	-
Zero-inflated Poisson	1172.139	1208.7871	1.296
Zero-inflated negative binomial	656.856	695.794	1.183

Source: Own elaboration.

Spatial effects

Once we had defined the econometric methodology, neighbouring effects also needed to be accounted for. The results may be biased and inconsistent if the location determinant effects of firm location decisions do not come only from the geographical limits of the area (i.e. neighbourhood). To account for this spatial dependence, we used the Moran Index (Moran, 1948) and the Local Indicator of Spatial Association (Anselin, 1995) to test if there is some spatial dependence across variables. For this reason, we propose 2 spatial models to explain the effect of spatial dependence on firm location determinants: the Spatially Lagged Covariates Model (SLX) and the Spatial Autoregressive

Poisson Model (P-SAR).[57] While the SLX model considers the spatially lagged variables of the independent variables, the P-SAR model considers the spatial autoregressive lag of the dependent variable. The first, the SLX model, is estimated as follows:

$$WX = W * X$$

where *W* is a row-standardized spatial neighbour matrix and *X* is a set of independent variables. The spatial neighbour matrix used follows the Queen Contiguity 1st order (i.e. it only takes into account the nearest 1[st] order neighbours). The spatial lagged variables were selected using the tests mentioned above.[58]

The P-SAR Model is a technique by Lambert et al. (2010) which formulates a two-step estimator for a spatial autoregressive lag model of counts. This technique can include the spatially lagged dependent variable in the model to explain if the dependent variable has any spatial dependence effect.

The first step (SAR estimation) involves replacing the spatially lagged, log-transformed counts in the y_i with their predicted values. Following Lambert et al. (2010), let the function $g(y_i)$ represent the logged-transformed values approximating neighbouring counts. As it is useful to formulate the problem with reference to a log-likelihood function, the log-likelihood function of the first-stage estimator is:

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[57] The use of spatial count data models in firm location is innovative since these models are commonly used in other fields such as Ecology, Biostatistics or Medicine (Glaser, 2017). They are an improvement, because they explain what effect the surrounding areas have on the present area.

[58] See variable selection according Moran Index, aspatial significance of the variable and correlation between X and WX (table A4.4) and the Local Indicator of Spatial Association of selected variables (Figure A4.5) in the Appendix D.

$$lnL_1 = \sum_{i=1}^{n} f_1(W \cdot g(y_i)|Q_i; \delta)$$

where $f_1$is the normal probability density function and δ a vector of parameters that maximizes L_1. So, given a set of appropriately defined instrumental variables ($Q = [X, WX, WWX]$), the instruments regressed on the transformation yield the vector of predicted values:

$$Q\delta \text{ with } \delta = Q(Q'Q)^{-1}Q'W \cdot g\left(y_j^*\right)$$

Then, in the second step, the first-stage predicted values enter the Poisson probability density function as:

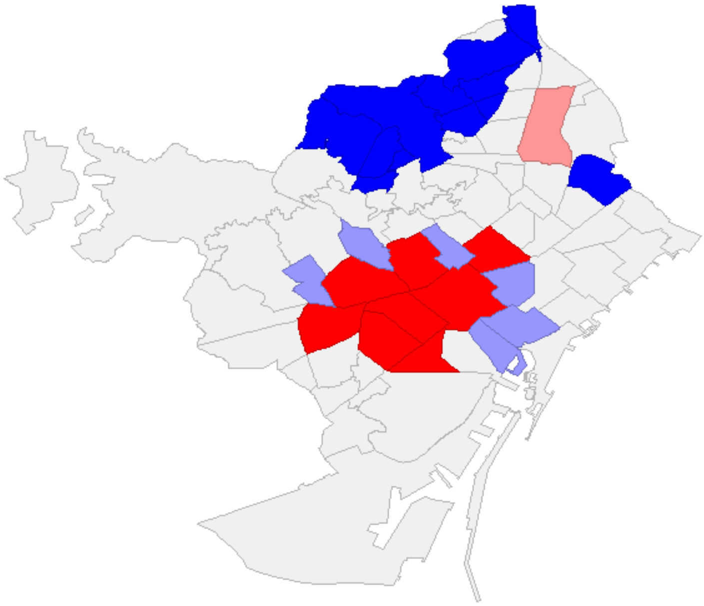
$$f(y|x, W, Q_i\delta'; \beta, \rho) = \frac{\exp\left(\beta' x_i + \rho \cdot Q_i'\delta\right)^{y_i} \exp\left(-\exp(\beta' x_i + \rho \cdot Q_i'\delta)\right)}{y_i!}$$

This is essentially a Poisson regression with an endogenous covariate. We apply this procedure only to explain the spatial effect of the dependent variable of SVE firm entries, since it seems that this variable has some spatial dependence (see Figure 4.2).[59]

[59] Our estimation follows a two-step LIML estimation. We solve the problem of zero counts by transforming the dependent variable with the inverse hyperbolic sine transformation (Burbidge et al., 1988). For more information about the technique and procedures, see Lambert et al. (2010).

Figure 4.2 Local indicator of spatial association (LISA) and Moran Index for SVE firm entries

***SVE_ent* (0.373)**



Source: Own elaboration. Note: Moran index in brackets. Red indicates neighbourhoods with a high value surrounded by neighbourhoods with a high value, light red means neighbourhoods with a high value surrounded by neighbourhood with a low value, light blue means neighbourhoods with a low value surrounded by neighbourhoods with a high value and blue means neighbourhoods with a low value surrounded by neighbourhoods with low value. Results after 999 permutations.

Unfortunately, the severe limitation of this technique is that it implies that all spatial dependency comes from observed covariates (Glaser, 2017). For this reason, we apply SLX to SVE, Creative and All firm entries and the P-SAR model only for SVE firm entries, since it is the only model which fits SVE firm entries and is the industry of interest in this chapter. The use of both models enables us to see the spatial effect of the dependent variable as well as the effect of the covariates on SVE firm entries.

4.4 Results

In this section, we present the results of our estimations. Table 4.5 gives our aspatial analysis (i.e. non-spatial approach) and Table 4.6 gives our spatial analysis (i.e. spatial approach).[60]

4.4.1 Aspatial analysis

Table 4.5 presents the main results without spatial effects.[61] In order to avoid multicollinearity problems, a combination of agglomeration variables has been made (first only with the stock of firms of the same type [i.e. stock of SVE, Creative and All firms] and second, only using the sum stock of VFI, ADV and RTV of firms [i.e. *Aggl10* variable]).

Table 4.5 Location determinants of firms (Aspatial)

	Software and Video Game firms		**Creative firms**	**All firms**
	PM		**NBM**	**NBM**
	(1)	(2)	(3)	(4)
Agglomeration Economies				
Loc10	0.00783***		0.00193***	0.000298***
	(0.00137)		(0.000361)	(6.11e-05)
Aggl10		0.00638***		
		(0.00109)		
High-Tech Amenities				
Wifi	0.0206**	0.0249***	0.0138**	0.0229**
	(0.00824)	(0.00780)	(0.00699)	(0.0104)
CTP	0.378*	0.474**	0.162	0.932***

[60] According to Cameron and Trivedi (2008), the coefficients can be interpreted as a semielasticity. Thus the coefficient of *Markets* of 0.101 in the first estimation can be interpreted as the presence of one more craft street market in the neighbourhood being associated with a 10.1% increase in the number of SVE entries. The average marginal effects of each estimation can be found in the Appendix D (Table A4.6 for the aspatial results and Table A4.7 for the spatial results).
[61] We include Creative and all firm entry models so that we can compare the effect of some variables across type of entry, and thus have a more complete and rigorous analysis (Hypothesis 1).

	(0.221)	(0.222)	(0.215)	(0.265)
Dist22	0.956***	0.902***	0.410*	-0.189
	(0.239)	(0.237)	(0.232)	(0.298)
Cultural and Creative Diversity				
Entropy	3.321***	3.359***	7.217***	2.635***
	(1.266)	(1.238)	(1.245)	(0.500)
Markets	0.101***	0.125***	0.0691***	0.0788**
	(0.0300)	(0.0323)	(0.0258)	(0.0386)
Human Capital				
University	0.0615**	0.0695***	0.0353	-0.0218
	(0.0271)	(0.0267)	(0.0286)	(0.0416)
Edu10	5.254***	4.361***	5.433***	2.718***
	(1.048)	(1.090)	(0.854)	(0.742)
Popd10	0.000941***	0.000982***	0.000749***	0.000544*
	(0.000323)	(0.000322)	(0.000269)	(0.000278)
Crime				
PolRat	-0.107**	-0.134***	-0.0537	0.00390
	(0.0435)	(0.0446)	(0.0330)	(0.0447)
Constant	-3.897***	-3.761***	-5.894***	0.154
	(0.865)	(0.842)	(0.915)	(0.335)
Observations	73	73	73	73
Non-zero observations	49	49	59	71
LR chi2	569.7	571.8	152.5	151.5
Log likelihood	-137.5	-136.4	-160.2	-310.1
Pseudo R-squared	0.674	0.677	0.323	0.196
/ln alpha			-3.124***	-1.501***
			(0.676)	(0.207)
alpha			0.0454	0.227
VIF	2.26	2.23	2.25	2.21

Note: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Loc10 refers to stock of the current type of firms in 2010. Poisson Model (PM), Negative Binomial Model (NBM).

For agglomeration economies, the previous presence of SVE firms and the combination of VFI, ADV and RTV firms in the neighbourhood positively affects the present location of SVE firms, as was shown by Méndez-Ortega and Arauzo-Carod (2019a). For Creative and All firm models we also found that the previous presence of this type of firm had a positive effect. These are expected results and consistent with previous empirical research.

High-tech amenities have a positive and statistically significant impact on SVE firm entries and this effect is lower for Creative and All firm entries. This proves the importance of these amenities for the industry (Li and Zhu, 2017; Woodward et al., 2006). It is important to highlight the positive and significant effect of the 22@ district for SVE firm entries, as Viladecans-Marsal and Arauzo-Carod (2012) have proved. Cultural and creative diversity also have an impact on SVE firm entries. The positive and significant coefficients associated with the Entropy index and markets show that places with a high diversity of creative firms, street markets and diversity are places where SVE firms choose to locate, as empirical evidence has suggested (Florida and Gates, 2003; Florida and Mellander, 2016). The positive impact of these variables is slightly lower than that of creative firm entries but higher than that of All firm entries.

Human capital variables are also important for high-tech firm entry decisions. We found that the presence of universities positively affects SVE firm entry decisions, while a high proportion of highly educated people and population density impacts positively on firm entry decisions for all models. These results are consistent with previous literature (Kinne and Resch, 2017). Finally, Crime negatively affects SVE and Creative firm location decisions, and is not significant for All entries. This shows that this type of firm tends to choose safe locations where there is no crime. These results contrast with those found by Goetz and Rupasingha (2002) and Hackler (2003), which showed a positive relationship between crime and entry growth rate of Software firms.

In summary, these results confirm hypothesis 1, showing a positive effect of Agglomeration economies, High-tech amenities, Creative and Cultural Diversity and Human capital variables on SVE firm entry decisions and a negative effect of Crime. These effects are different across types of firm. Nevertheless, to test the second hypothesis – that is, whether the impact of certain variables transcends neighbourhood borders – a spatial analysis needs to be done.

4.4.2 Spatial analysis (SAR-Poisson and Spatial Lag)

Table 4.6 presents the main results with spatial effects. The first column gives the results of the P-SAR model for SVE firm entries and the remaining five columns give the results of the SLX model for SVE, including spatial agglomeration variables (2), the spatial high-tech amenities variable (3), the spatial Creative and cultural diversity variable (4), the spatial Human capital variable (5) and the spatial Crime variable (6).

Table 4.6 Location determinants of firms (P-SAR and SLX models)

	Software and Video Game firms					
	P-SAR	SLX				
	(1)	(2)	(3)	(4)	(5)	(6)
Agglomeration Economies						
Sve10		0.00763***	0.00843***	0.00853***	0.0115***	0.0114***
		(0.00137)	(0.00144)	(0.00144)	(0.00159)	(0.00161)
High-Tech Amenities						
Wifi	0.0411***	0.0218***	0.0203**	0.0225***	0.0186**	0.0206**
	(0.00764)	(0.00830)	(0.00836)	(0.00847)	(0.00876)	(0.00903)
CTP	0.199	0.531**	0.636***	0.809***	1.361***	1.425***
	(0.239)	(0.240)	(0.245)	(0.269)	(0.311)	(0.315)
Dist22	1.041***	0.966***	0.632**	0.579**	0.0126**	0.00298*
	(0.240)	(0.240)	(0.288)	(0.290)	(0.320)	(0.321)
Cultural and Creative Diversity						
Entropy	1.843	2.933**	3.146**	4.136***	4.088***	3.917***
	(1.193)	(1.235)	(1.258)	(1.384)	(1.383)	(1.372)
Markets	0.0620*	0.0919***	0.0965***	0.0991***	0.0563*	0.0762**
	(0.0323)	(0.0308)	(0.0311)	(0.0313)	(0.0320)	(0.0368)
Human Capital						
University	0.0932***	0.0356*	0.0341*	0.0201*	0.0289*	0.0367*
	(0.0274)	(0.0316)	(0.0316)	(0.0329)	(0.0385)	(0.0396)
Edu10	5.574***	4.574***	3.900***	4.469***	2.629*	2.989**
	(1.554)	(1.127)	(1.158)	(1.232)	(1.412)	(1.449)
Popd10	0.000559	0.000758**	0.000665*	0.000779**	0.000854**	0.000844*
	(0.000396)	(0.000345)	(0.000347)	(0.000361)	(0.000390)	(0.000394)
Crime						

PolRat	-0.0532	-0.112***	-0.114***	-0.115***	-0.00295*	-0.0224*
	(0.0375)	(0.0432)	(0.0429)	(0.0428)	(0.0527)	(0.0553)
Spatial Variables						
ϱ	0.0866**					
	(0.0351)					
w_Sve10		0.00382	0.00460*	0.00585**	0.0157***	0.0158***
		(0.00240)	(0.00243)	(0.00253)	(0.00342)	(0.00343)
w_Dist22			0.874**	1.023**	1.344***	1.239***
			(0.412)	(0.424)	(0.412)	(0.421)
w_Entropy				-2.636*	-0.433	-0.287
				(1.566)	(1.718)	(1.714)
w_PolRat					-0.398***	-0.391***
					(0.0908)	(0.0910)
w_University						-0.0989
						(0.0875)
θ	0.338**					
	(0.156)					
Constant	-3.095***	-3.418***	-3.444***	-2.565***	-3.248***	-3.228***
	(0.852)	(0.866)	(0.874)	(0.949)	(1.061)	(1.049)
Observations	73	73	73	73	73	73
Non-zero observations	49	49	49	49	49	49
LR chi2	537	572.2	576.2	578.8	600.6	601.9
Log likelihood	-153.8	-136.2	-134.2	-132.9	-122	-121.4
Pseudo R-squared	0.636	0.677	0.682	0.685	0.711	0.713

Note: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Poisson Spatial Autoregressive Model (P-SAR), Spatial Lag Model (SLX).

For the P-SAR model, most of the key location determinant variables remain significant as in the previous estimation. The autoregressive coefficient (ρ) is statistically significant, which suggests that SVE firm neighbouring entries are important and explain SVE firm entries.[62] This effect is explained by agglomeration economies, caused by the knowledge spillovers between firms, as literature and empirical evidence has proved. This determinant is much more intense in SVE firms, in which innovation and success is very closely tied to the talents of workers (Andersson et al., 2009). The impact of high-tech amenities remains positive and significant (except for technology parks) as does the effect of craft street markets.

For the SLX models (2-6), almost all the key location determinants considered in the aspatial model remain positive and significant. In the case of lagged variables (*w_*), the presence of Software firms around the neighbourhood (*w_Sve10*) positively affects the location of SVE firms for all models except the first one. For the spatial lag of the High-tech variable, estimation (3) shows that there is a positive and significant effect on SVE entries in the neighbourhoods surrounding the 22@ district, because of the importance of this high-tech district in attracting knowledge activity (Viladecans-Marsal and Arauzo-Carod, 2012).

Moreover, in the case of the Entropy index variable, the effect of including the spatial lag variable is negatively significant in (4) but not significant in (5-6), so diversity beyond borders does not affect SVE firm entry decisions. The spatial lag of crime is negatively significant, which shows that the presence of crime in surrounding neighbourhoods

[62] In this first estimation, the previous stock of SVE firms was not considered because of the high correlation with the autoregressive component.

also negatively affects SVE firm entries. Finally, the spatial lag of universities is not statistically significant in our SLX model.

Therefore, we almost confirmed Hypothesis 2 because, on the one hand, Agglomeration Economies and High-tech amenities have a positive impact and Crime a negative impact on SVE firm entries but, on the other hand, we found that the effect is not significant for all the variables beyond the borders (Entropy and University variables).

In summary, these results show that *i*) agglomeration economies, high-tech amenities and cultural and creative diversity are important factors in SVE firms' decisions to locate in a particular place within the city, and that these factors are different from those that affect the decisions of Creative and All firm entries. *ii)* In terms of spatial effects, the SLX model shows that there is a spatial effect beyond neighbourhood borders for SVE firm entries, since almost all the lagged variables (*w_*) in SVE firm entry models were significant (except *w_Entropy* and *w_Universities*). Nevertheless, the P-SAR model shows a spatial effect in the dependent variable (*SVE firm entries*), which indicates that there is a positive spatial autoregressive effect (SVE firm entries are affected by surrounding SVE entries in the same period).

Robustness checks

We carried out a series of tests on the robustness of our results. First, we analysed whether location patterns and effects of location determinants are the same for different firm sizes. The results were similar. Second, we tried to include variables such as distance from Plaça Catalunya (the cultural centre of Barcelona), the number of coworking spaces and the number of civic centres (e.g. places where people who live in the neighbourhood can do recreational activities, normally located in deprived areas), but these variables were not significant. Third, we used different criteria to select the spatial lagged variables (table A4.4), but we tried to include the rest of variables and we obtain non-significant results for these variables. Fourth, we used different spatial neighbour matrices (5 k-nearest neighbours' matrix and Rook contiguity matrix) to test if the spatial effect varies. We observed that in the case of the P-SAR model, the more neighbours the matrix contains, the more diluted the effect of the autoregressive coefficient is (see Table A4.8 in the Appendix D). In the case of the SLX models, the results were similar, with the best choice being the 1st order Queen Contiguity matrix.

4.6 Conclusions

This chapter has analysed the main location determinants of Software and Video Game firms in the city of Barcelona. In recent decades, this industry has changed the way in which people, firms and societies interact. Its impact on the current world economy is constantly growing, which makes it one of the most important industries in the world. Despite being an industry that is located mainly in cities, most empirical research on the location determinants of high-tech firms has been done at regional or country level.

So this chapter has contributed to the literature by providing empirical evidence on the location determinants of this industry at urban level, and dealing with factors that have not been taken into account, or have not been analysed together on this scale. Our main results show that SVE firms tend to choose locations with good high-tech amenities, a high diversity of creative firms and a presence of SVE and similar firms (i.e. agglomeration economies). Our hypothesis was confirmed since we found a positive effect of Agglomeration economies, High-tech amenities, Creative and Cultural Diversity and Human capital variables on SVE firm entry decisions and a negative effect of Crime. The methodological approach used in this chapter provides a more in-depth understanding of the location strategies of these firms and supplements previous contributions with a methodology that has rarely been used in empirical studies because of its complexity.

These results raise some interesting issues for policy makers. To date, it has largely been assumed that SVE firms are located in places with technological facilities, human capital and good infrastructures in general. This chapter has shown that these characteristics are indeed important, but so is cultural and creative diversity. These considerations can be extended to other cities from both developing and developed countries. Hence, the promotion and attraction of creative activities, in conjunction with the factors mentioned above, will contribute to the location of SVE activities, which are of fundamental importance to economic growth and will boost the economic development of cities.

Nevertheless, this chapter has some limitations that we intend to address in further research. Although the unit of analysis is small (i.e. neighbourhood), it must be taken into account that there is a modifiable areal unit problem (MAUP). Moreover, the chapter deals with a specific city and period of time. Further research should explore all these concerns in other to provide more robust results.

Appendix D

See Table A4.1, A4.2, A4.3, A4.4, A4.6, A4.7, A4.8 and Figure A4.5.

Table A4.1 List of creative industries

Nº	Creative industries	Acronym	NACE 2009 Codes
1	Advertising and related services	ADV	731
2	Architecture and engineering	AE	711
3	Art and antiques trade	ART	4779
4	Craft and performing arts	CPA	90
5	Cultural tourism and recreational services	TRS	93
6	Publishing	ED	581
7	Fashion	FA	14, 1511, 152
8	Graphic arts	GA	181
9	Heritage, cultural sites and recreational services	HE	91
10	Creative research and development	IDC	721, 722
11	Jewellery, musical instruments, toys and games	JEW	321, 322, 324
12	Music and music studies	MU	182, 592
13	Photography	PHO	742
14	Radio and TV	RTV	601, 602
15	Software, Video Game and Editing Electronics	SVE	620, 582
16	Specialised services design	SSD	741
17	Video and film industries	VFI	591

Source: Own elaboration based on UNCTAD (2010)

Table A4.2 Determinants of rent price in Barcelona by neighbourhood (2011)

	Rent Price			
	SVE firms		Creative firms	All firms
	(1)	(2)	(3)	(4)
Loc10	-0.00980**		-0.00231*	-0.000226*
	(0.00467)		(0.00116)	(0.000129)
Aggl10		-0.00643*		
		(0.00352)		
Wifi	-0.00140	-0.00955	-0.00796	-0.00920
	(0.0237)	(0.0225)	(0.0223)	(0.0230)
CTP	0.509	0.452	0.467	0.479
	(0.512)	(0.517)	(0.514)	(0.517)
Dist22	0.137	0.160	0.179	0.0224
	(0.583)	(0.587)	(0.585)	(0.592)
Entropy	-0.0329	-0.0637	-0.0564	0.0338
	(0.895)	(0.905)	(0.899)	(0.902)
Markets	0.0386	0.0238	0.0293	0.0445
	(0.0801)	(0.0816)	(0.0808)	(0.0809)
University	0.00641	0.000828	0.00401	0.00450
	(0.0872)	(0.0878)	(0.0874)	(0.0883)
Edu10	15.45***	15.59***	15.80***	15.34***
	(1.644)	(1.680)	(1.692)	(1.659)
Popd10	0.00178***	0.00174***	0.00175***	0.00177***
	(0.000501)	(0.000509)	(0.000505)	(0.000509)
PolRat	0.0530	0.0797	0.0830	0.0621
	(0.0872)	(0.0883)	(0.0880)	(0.0879)
Constant	4.978***	4.990***	4.959***	4.980***
	(0.510)	(0.515)	(0.512)	(0.516)
Observations	73	73	73	73
R-squared	0.755	0.751	0.753	0.750

Note: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Loc10 refers to stock of the current type of firms in 2010.

Table A4.3 Correlation matrix

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1)	***Wifi***	1								
(2)	***CTP***	-0.096	1							
(3)	***Dist22***	0.096	0.108	1						
(4)	***Entropy***	0.412*	0.066	0.133	1					
(5)	***Markets***	0.346*	-0.083	-0.042	0.223	1				
(6)	***University***	0.162	0.517*	-0.008	0.206	0.052	1			
(7)	***Edu10***	0.475*	0.099	-0.065	0.583*	0.138	0.385*	1		
(8)	***Popd10***	0.073	-0.234*	0.211	0.208	0.114	-0.137	-0.252*	1	
(9)	***PolRat***	0.664*	0.081	-0.017	0.448*	0.607*	0.190	0.307	0.174	1

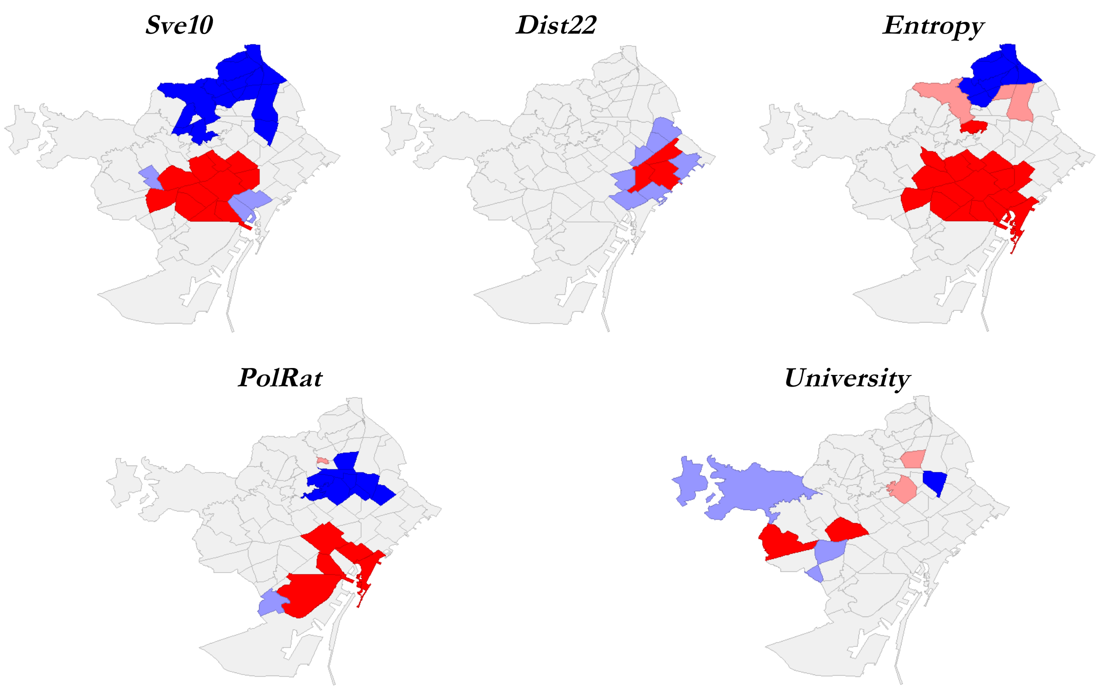
Source: Own elaboration. Note: (*) Significance level at 5%.

Table A4.4 Selection of Spatial Lag variables (SLX Model)

Variable	Correlation with WX	Moran I	Sig. Aspatial	SLX Model
Sve10	0.574*	0.406	Yes	Yes
Wifi	0.618*	0.447	Yes	No
CTP	0.134	0.060	Yes	No
Dist22	0.472*	0.343	Yes	Yes
Entropy	0.739*	0.566	Yes	Yes
Markets	0.089*	0.046	Yes	No
PolRat	0.668*	0.478	Yes	Yes
University	0.291*	0.143	Yes	Yes
Edu10	0.841*	0.681	Yes	No
Popd10	0.385*	0.240	Yes	No

Source: Own elaboration. Note: Sig. Aspatial indicates whether this variable was significant in the aspatial model.

Figure A4.5 Local indicator of spatial association (LISA) for selected SLX model variables



Source: Own elaboration.

Table A4.6 Location determinants of firms (Aspatial). Average Marginal Effects.

	Software and Video Game firms		**Creative firms**	**All firms**
	PM		**NBM**	**NBM**
	(1)	(2)	(3)	(4)
Agglomeration Economies				
Loc10	0.03506***		0.02319***	0.03153***
	(0.06433)		(0.00515)	(0.01166)
Aggl10		0.02661***		
		(0.00464)		
High-Tech Amenities				
Wifi	0.0922**	0.116**	0.166*	2.421*
	(0.03724)	(0.0350)	(0.0851)	(1.260)
CTP	1.954*	2.855*	1.945	98.464***
	(1.369)	(1.561)	(2.587)	(35.845)
Dist22	6.618***	5.814***	4.923*	-19.946
	(2.542)	(2.353)	(2.796)	(31.845)
Cultural and Creative Diversity				
Entropy	14.877***	14.909***	86.713***	278.361***
	(5.730)	(5.577)	(16.051)	(73.682)
Markets	0.453***	0.562***	0.829***	8.321**
	(0.137)	(0.1485)	(0.312)	(4.119)
Human Capital				
University	0.276**	0.278***	0.424	-2.307
	(0.122)	(0.121)	(0.341)	(4.527)
Edu10	23.535***	19.434***	65.274***	287.099***
	(4.873)	(4.980)	(10.872)	(95.489)
Popd10	0.004213***	0.004353***	0.008999***	0.057426*
	(0.001467)	(0.001460)	(0.003235)	(0.031122)
Crime				
PolRat	-0.477**	-0.608***	-0.646	0.412
	(0.196)	(0.202)	(0.397)	(4.731)

Note: Standard errors in parentheses *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Loc10 refers to stock of the current type of firms in 2010. Poisson Model (PM), Negative Binomial Model (NBM). With Average Marginal Effects, the interpretation of the coefficients is direct (e.g. for the first estimation, one more Wi-Fi Hotspot in the neighbourhood is associated with 0.0922 additional SVE entries).

Table A4.7 Location determinants of firms (P-SAR and SLX models). Average Marginal Effects.

	Software and Video Game firms					
	P-SAR	SLX				
	(1)	(2)	(3)	(4)	(5)	(6)
Agglomeration Economies						
Sve10		0.03418***	0.03775***	0.03820***	0.05143***	0.05119***
		(0.00643)	(0.03777)	(0.00679)	(0.00765)	(0.00772)
High-Tech Amenities						
Wifi	0.184***	0.0979***	0.0908**	0.1008***	0.0833**	0.0924**
	(0.0357)	(0.0376)	(0.0377)	(0.0383)	(0.0395)	(0.0407)
CTP	0.956	2.933*	3.690*	5.095**	11.484**	12.475**
	(1.267)	(0.240)	(1.910)	(2.455)	(4.749)	(5.124)
Dist22	7.543***	6.728***	3.718*	3.316*	0.0565	-0.0133
	(2.759)	(2.579)	(2.271)	(2.180)	(1.447)	(1.435)
Cultural and Creative Diversity						
Entropy	8.254	13.136**	14.090**	18.526***	18.309***	17.544***
	(5.364)	(5.581)	(5.687)	(6.284)	(6.276)	(6.220)
Markets	0.278*	0.412***	0.432***	0.445***	0.252*	0.341**
	(0.145)	(0.140)	(0.142)	(0.1432)	(0.144)	(0.166)
Human Capital						
University	0.418***	0.159	0.152	0.0899	-0.309*	-0.344*
	(0.125)	(0.141)	(0.141)	(0.147)	(0.174)	(0.178)
Edu10	24.969***	20.489***	17.467***	20.018***	11.777*	13.389**
	(7.095)	(5.172)	(5.275)	(5.630)	(6.360)	(6.533)
Popd10	0.002505	0.003394**	0.001565*	0.003491**	0.003824**	0.003782**
	(0.001781)	(0.001554)	(0.000347)	(0.001627)	(0.001761)	(0.001779)

Crime						
PolRat	-0.238	-0.499***	-0.511***	-0.516***	-0.0131*	-0.100
	(0.168)	(0.195)	(0.194)	(0.193)	(0.236)	(0.247)
Spatial Variables						
ρ	0.388**					
	(0.132)					
w_Sve10		0.0171	0.0206*	0.0261**	0.0704***	0.0708***
		(0.011)	(0.0109)	(0.011)	(0.016)	(0.016)
w_Dist22			3.915**	4.584**	6.018***	5.548***
			(1.857)	(0.191)	(1.877)	(1.911)
w_Entropy				-11.809*	-1.939	-1.285
				(7.046)	(7.695)	(7.679)
w_PolRat					-1.784***	-1.752***
					(0.418)	(0.419)
w_University						-0.443
						(0.392)

Note: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Poisson Spatial Autoregressive Model (P-SAR), Spatial Lag Model (SLX).

Table A4.8 Neighbour matrices test for the P-SAR model

W matrix	(1) 1st Order Queen Contiguity	(2) 5-k nearest neighbours	(3) 1st Order Rook Contiguity
ρ	0.0866**	0.0317*	0.0774**
	(0.0351)	(0.0176)	(0.0667)
Constant	-3.095***	-3.408***	-3.128***
	(0.852)	(0.838)	(0.859)
θ	0.338**	0.371**	0.335**
	(0.156)	(0.166)	(0.154)
AE var.	Yes	Yes	Yes
HTA var.	Yes	Yes	Yes
CCD var.	Yes	Yes	Yes
HC var.	Yes	Yes	Yes
Crime var.	Yes	Yes	Yes
Observations	73	73	73
Non-zero observations	49	49	49
LR chi2	537	535.6	536.6
Log likelihood	-153.8	-154.5	-154
Pseudo R-squared	0.636	0.634	0.635

Standard errors in parentheses. Notation: *** p<0.01, ** p<0.05, * p<0.1. Note: This table only shows main results; the rest of the results are available upon request.

Chapter 5

Concluding remark

The Software and Video Game industry (SVE) has revolutionized the way in which people, firms and institutions coordinate and work. Its impact on the world economy is constantly growing, which makes it, according to some researchers and institutions, one of the most influential industries in the world. This thesis has focused on the strategic importance of the industry for more developed economies. Despite being an industry that is located mainly in cities, most empirical research on the location determinants of high-tech firms has been done at regional or country level and very little is known about specific location patterns and, in particular, whether they tend to co-locate close to other creative industries. In this context, this thesis has contributed to the literature on high-tech industries by analysing their location patterns at the urban level with a wide range of methodological tools (spatial econometrics, distance-based methods and geographical information systems techniques, among others). The main results showed that SVE firms tend to co-locate with creative industries, and that this co-location is the same across several metropolitan areas. Moreover, this thesis has revealed the location determinants of the industry and, although these determinants are not so different from the determinants of these creative and non-creative firms, SVE firms tend to choose locations with a high diversity of cultural and creative activity, and good high-tech amenities. This concluding chapter summarises these main findings and discusses several implications, limitations and further extensions.

The second chapter focuses on the main tenets of recent empirical literature and analyses the location patterns of specific industries at very detailed geographical levels. It shows that SVE firms follow similar patterns to other service industries by tending to cluster around central areas in the city and its metropolitan area. To this end, it uses the micro-geographical data of firms located in the metropolitan area of Barcelona (MAB) in 2015. The results confirm the main hypothesis, as it shows how and where SVE firms cluster in a few core locations. In this respect, it also shows that the characteristics of firms partially help to explain their location preferences, as smaller/younger firms behave in a different way to larger/older firms. It also uses global (Moran's I) and local measures (LISA) to test whether the location of firms in this industry is spatially autocorrelated. The M-function results validate previous conclusions from spatial autocorrelation measures and suggest further insights for SVE firms. In particular, they contextualize SVE firms in terms of the location patterns of creative industries. So this chapter contributes to the literature by identifying how SVE firms concentrate in core areas of the metropolitan area and how these firms co-locate with other creative firms.

The third chapter analyses whether the location patterns and co-location strategies of SVE firms are similar across a sample of three European cities and metropolitan areas (Barcelona, Lyon and Hamburg) where these activities are of considerable importance. This chapter also used the micro-geographical data of firms from these metropolitan areas in 2015. This chapter showed the existence of intra-urban agglomeration in economic activity, especially for the creative industries. More specifically, these results indicate that although software firms in Europe typically tend to locate close to core locations, the location patterns of the SVE industry in comparison of those of creative industries at the city/metropolitan level can be divided into (at least) three models: the first one is a strong concentrated pattern (as in Hamburg), the second one is an intermediate (polycentric) agglomeration pattern (as in Barcelona) and the third one is an important agglomeration (*intramuros*) pattern (as in Lyon). Obviously, these differences are triggered by specific local policies, urban structures, path dependence on previous spatial configuration of economic activity, and general city and metropolitan characteristics but, in general terms, they confirm that creative industries do not follow a single agglomeration strategy.

Finally, the fourth chapter analyses the entry determinants of SVE firms at the urban level. The empirical application focuses on the city of Barcelona for the period 2011-2013 and uses Count Data and Spatial Models to explain SVE entry decision at the neighbourhood level. The main results of this chapter show that SVE firms tend to choose locations with good high-tech amenities, a high diversity of creative firms and a presence of SVE and similar firms (i.e. agglomeration economies). The main hypothesis was confirmed, since it was found that Agglomeration economies, High-tech amenities, Creative and Cultural Diversity and Human capital variables had a positive effect on SVE firm entry decisions and Crime had a negative effect. So this chapter has contributed to the literature by providing empirical evidence on the location determinants of this industry at the urban level, and dealing with factors that have not been jointly analysed on this scale.

5.1 Policy Implications

The aforementioned results have important implications for policies aiming to attract and encourage the local development of firms in the SVE industry, as they provide key facts about the locational preferences of firms in these industry. Therefore, it is worth making some final comments on the external validity and policy implications of the findings of this thesis.

First, policymakers should take these firms' preferences into account so that they can provide them with services and help improve accessibility to required inputs (e.g., research centres, incubator services, accessibility to skilled labour, forums where they can interact with other firms, etc.), which could make a metropolitan area even more appealing. In this regard, policy makers should focus on providing and improving those urban features and conditions that enhance the activity of SVE firms.

Second, this thesis gives evidence that SVEs co-locate with other creative firms and that this co-location is quite similar between metropolitan areas. This suggests that the policies to be implemented should depend on the specificities of each metropolitan area. In this regard, one of the main goals of policy makers should be the ex-ante identification of the agglomeration preferences of this industry for a given metropolitan area, in order to decide whether or not to increase existing agglomerations through, for instance, specificities of urban renewal projects aiming to attract SVE firms.

Third, it has largely been assumed that SVE firms are located in places with technological facilities, human capital and good infrastructures in general. This thesis has shown that these characteristics are indeed important, but so is cultural and creative diversity. Hence, the promotion and attraction of creative activities, in conjunction with the factors mentioned above, will contribute to the location of SVE activities, which are of fundamental importance to economic growth and will boost the economic development of cities.

5.2 Limitations and Further Research

To conclude, the limitations of this thesis may provide some guidance for future work that would lead to greater insight into the location determinants of SVE firms in metropolitan areas.

First, chapters 2 and 3 focus on the official definition of each metropolitan area, but the same areas can also be classified from a functional point of view. This aspect could be further investigated to determine how different metropolitan area classifications can be used to see if location and co-location patterns persist.

Second, this thesis makes a cross-sectional analysis, which could be further extended by incorporating temporal dynamics. In this respect, the use of different time periods would make it possible to diminish the bias caused by the business cycle and to identify whether there are any differences in the location and co-location strategies of these firms over time.

Third, this thesis focuses on only three cities and their metropolitan areas, and may reflect some effects that are city-specific and not relevant to all areas, although these cities cover a wide typology of urban areas. In this regard, extending this research to other areas would lead to a better understanding of the location of these firms and would help to design better policies to attract SVE firms.

Fourth, this thesis has mainly analysed the location patterns of SVE firms at the metropolitan/urban level, since the second and third chapter focus on the location and co-location of SVE firms in the city and the fourth chapter focuses mainly on entry determinants (*i.e.* what leads SVE firms to choose a specific neighbourhood in the city). In order to fully understand why these firms locate where they do, it would be interesting to identify and analyse location from all perspectives: i) co-agglomeration patterns, ii) location determinants, and iii) co-agglomeration determinants. Thus, an interesting extension to this research would be to analyse what determines the co-agglomeration of this industry with other creative/non-creative industries (e.g. input-output trade relations of this industry with other industries or the sharing of the same labour pool). This extension would cover all aspects of the location of this industry, since the second and third chapter show and prove this co-agglomeration, but do not go deeply into what determinants are behind this effect.

Fifth, this thesis analyses SVE firms and their location in urban areas. It has shown that SVE firms share the same co-location patterns but differ in their location patterns (e.g. the metropolitan area of Barcelona has a polycentric pattern while Hamburg has a more concentrated pattern). The third chapter shows that an ex-ante identification of the agglomeration preferences of this industry for a given metropolitan area could help in the design of better policies (i.e. urban renewal projects) for attracting SVE firms, and also that these urban sub-centres will influence other industries and contribute to the emergence of new firms because the number of people working and/or living in the new area will increase. Therefore, the creation of new sub-centres to attract SVE firms will also help attract new commercial establishments to provide amenities and services for newcomers, thus having a positive indirect impact on the economic growth of cities. This would lead to a better understanding of the real impact that SVE firms have on economic growth. Not only do they create jobs, they also bring new establishments to the area to meet the needs of the people who live and/or work there.

To sum up, further research should mainly focus on the fourth and fifth points, since work on these issues would increase our knowledge of the SVE firm location and its effects on other economic sectors

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