Location of Co-Working Spaces: A City Approach

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Abstract:

The present paper investigates the location patterns and the effects co-working spaces (CWS) generate on the urban context. The focus is on Barcelona, one of the most important creative hubs in Europe in terms of knowledge-based, creative, digital, and sharing economy, and the city hosting the largest number of co-working spaces in Spain. The paper addresses three main questions: 1) Which are the location patterns of co-working spaces in Barcelona? 2) Do CWS agglomerate in the same areas? And, 3) Do CWS coagglomerate with specific firm activities? To do that, this paper uses open data on Barcelona neighbourhoods' socioeconomic composition provided by the Statistics Department of the Council of Barcelona and micro-geographic data of private CWS and creative labs in Barcelona. By using Geographical Information Systems (GIS) and Kd functions of agglomeration and coagglomeration, results show that CWS are highly concentrated in central areas of Barcelona where there are greater chances to meet customers and suppliers, the proximity to urban amenities and the fact of being associated to an specific place-image. Moreover, they coagglomerate with specific kinds of firms and to those most related to creative industries. These results are relevant when assessing what it should be the actual goal of urban policies in Barcelona.

Keywords: co-working spaces, distance-based methods, agglomeration, coagglomeration, Barcelona

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1. MOTIVATION

Co-working spaces[1] (hereinafter, CWS) have become a global phenomenon over the last decade. According to Deskmag (2018), the number of CWS has increased by 18% from 2011 to 2017, which puts the number of CWS worldwide at around 15,500 by the end of 2017. Although the CWS phenomenon remains concentrated in the main advanced – and so-called 'creative' – cities of the world, office space competition is increasing in several regional capitals (Cushman & Wakefield 2018). The increasing demand for such open working spaces turns into a new concern for urban policies since it may have many implications for the city socioeconomic and living conditions. Despite their increasing importance, not so often their location patterns and drivers at the urban level are addressed (see for instance, Moriset 2014; Mariotti et al. 2017).

When it comes to understand the sudden rise of CWS in the most important world cities, the rise both of the digital and the creative economy and the emergence of new ways of organising labour may explain this phenomenon (Moriset 2014). Geographical proximity facilitates the transmission of tacit knowledge leading to a competitive advantage to those individuals who share it. In a digital economy context, but, one may think that the spread of information technology systems facilitate more than ever before flexible job locations and teleworking (Moriset and Malecki 2009; Bizzarri 2014). Still, even the digital economy features explain location patterns of both dispersion and concentration (Moriset and Malecki 2009; Moriset 2014), knowledge-based, digital and creative jobs are still primarily concentrated in large urban areas (Florida 2005; Moriset 2014; Arauzo-Carod et al. 2017; Coll-Martínez et al. 2018). In this context, freelancers and independent workers find several advantages in working in CWS since proximity facilitates knowledge transfer, informal exchange, cooperation, horizontal interaction with others, networking and business opportunities (Boschma 2005).

Furthermore, the exponential growth of CWS may have positive or negative effects on the urban economy (Chuah 2016). On the one hand, they can be a strategic tool to facilitate the development of creative cities, since they can reinforce the concentration of high-skilled creative workers, as well as drivers of urban revitalisation, community building and

[1] Co-working spaces are innovative workplaces where independent knowledge-based, creative, and digital workers – mainly freelancers or self-employed professionals – share their work spaces. They rent a desk (for months, days, or even just hours) in return for different kinds of services: both traditional (such as, for instance, administrative offices, meeting rooms, or spaces of aggregation) and digital (such as, for instance, wifi.connections, or printers) (Mariotti et al. 2017).

improvement of surrounding public spaces (Florida 2002, 2005; Scott 2014; Moriset 2014; Mariotti et al. 2017). On the other hand, but, this fact also implies some risks related to a potential co-working "bubble" and real estate speculation (Moriset, 2014), leading to increasing housing and office prices, gentrification or increasing inequalities in the core neighbourhoods of big cities.

The aim of this paper is, therefore, twofold. First, it aims to analyse the location patterns of CWS within the city of Barcelona in order to understand where they locate and why; and second, it analyses the potential interaction effects with the urban business demography by analysing their coagglomeration with the specific kinds of economic activity. Specifically, the paper addresses three main research questions: 1) Where do CWS spaces locate in Barcelona? 2) Why do CWS agglomerate in the same areas? And, 3) Do CWS coagglomerate with firms working in specific economic activities? The answer to these questions may be relevant when assessing what it should be the actual goal of urban policies in terms of urban socioeconomic and living conditions in Barcelona. To do that, this paper uses open data on Barcelona neighbourhoods' socioeconomic composition provided by the Statistics Department of the Council of Barcelona and micro-geographic data of private CWS located in Barcelona taken by different public sources. To deal with methodological limitations arising from the use of geographically aggregated data and area-based methods, we use geo-referenced data for the city of Barcelona in order to analyse their location patterns and also to calculate the distance-based Kd functions of agglomeration and coagglomeration (Duranton and Overman 2005; 2008) with creative industries (hereinafter, CIs) firms.

Our paper adds to a growing literature on the CWS phenomenon at the urban level (Gandini 2015). However, this is the first paper to use Geographical Information Systems (GIS) and distance-based measures to analyse the agglomeration of CWS and their coagglomeration with specific kinds of economics activities at the intra-city level. The Kd function provides information on the CWS localisation, that is, the tendency for CWS to cluster relative to overall economic activity at a given distance. Concretely, the Kd function compares the distribution of distances between pair of establishments in an economy to that of hypothetical industries with the same number of establishments randomly distributed across all the area under consideration (Duranton and Overman 2005; 2008). Moreover, this methodology allows us to test whether there are some inter-sectorial interdependencies with specific economic activities, such as CIs and non-CIs by distinguishing by their size (in terms of number of employees) and their main knowledge-

base. These comparisons are interesting because differences in location patterns may inform us about factors driving CWS location.

The focus is on Barcelona, one of the most important creative hubs in Europe in terms of knowledge-based, creative, digital, and sharing economy (Barcelona City Council and IERMB 2013; CITIE 2015). Actually, the Catalan capital has been recently highlighted for its potential as the European city with the greatest growth margin in terms of co-working spaces creation in the coming years (Cushman & Wakefield 2018). Despite the importance of Barcelona, there is little evidence on the location patterns and interaction effects of CWS with the economic activity in the city (except for Capdevila 2013; 2014). Against this background, our work provides notable implications. Analysing the agglomeration and coagglomeration of CIs from a continuous space point of view enables us to identify whether this new real state phenomena, attracting the most innovative start-ups and creative free-lancers, tends to cluster, and how intense its agglomeration within Barcelona is. Moreover, several recent studies have found that Barcelona already has great potential as a magnet for the young and skilled population but little potential to distribute this population among the various parts of the city (López-Gay 2016). Together with the expected growth in office spaces for CWS in the city, policies dealing with urban regeneration and real state regulations should therefore be reshaped in accordance with the intensity of the agglomeration of the CWS.

Our main results suggest that CWS are highly concentrated in the most central areas of Barcelona, since there are greater chances to meet customers and suppliers, the proximity to urban amenities and the fact of being associated to a specific place-image. Also, because of the opportunity they offer to (creative) free-lancers to operate in the most vibrant areas of the city by paying a more competitive fee than if they were renting a full office or apartment. Moreover, our Kd-function results show that: 1) CWS are significantly agglomerated at short distances and this agglomeration rapidly disappears when distance increases; and 2) that there is a clear coagglomeration between CWS and CIs firms (specifically, with symbolic and synthetic-based CIs firms), while there is not significant coagglomeration with non-CIs, possibly because they are in less need of tacit interaction and specific environments than symbolic-based CIs.

The remaining of the paper is structured as follows. In Section 2 we review the main factors behind the location of co-working spaces and its relationships with creative industries. In section 3 we present our methodological approach and data. In Section 4 we

analyse the location patterns of CWS in Barcelona. Finally, in Section 5 we discuss our main conclusions.

2. CWS IN CITIES

Since the 2000's, the global economy have seen the proliferation of three interlinked movements: the creative economy[2] (Florida 2002), the spread of the information and communication technologies (Malecki and Moriset 2008) and the sharing economy[3] (Botsman and Rogers 2011). All these movements pick up speed after the economic crisis of 2007 because of the structural changes in the general labour market (particularly, in the creative industries) and new ways of organisation of work (Merkel 2014). It is precisely in this context where CWS emerge as "`serendipity accelerators', designed to host creative people and entrepreneurs who endeavour to break isolation and to find a convivial environment that favours meetings and collaboration" (Moriset 2014).

Even there is no an official definition for such an innovative workplace, Gandini (2015, pp. 194-195) defines CWS as "shared workplaces utilised by different sorts of knowledge professionals, mostly freelancers, working in various degrees of specialisation in the vast domain of the knowledge industry. Practically conceived as office-renting facilities where workers hire a desk and a wifi connection these are, more importantly, places where independent professionals live their daily routines side-by-side with professional peers, largely working in the same sector – a circumstance which has huge implications on the nature of their job, the relevance of social relations across their own professional networks and – ultimately – their existence as productive workers in the knowledge economy".[4] However, some authors claim that its meaning is far from clearly defined since not all shared offices that use the term co-working can be considered as such. According to Capdevila (2014), the most important feature that defines a CWS is the sense of

[2] The creative economy is based on the concentration of creative people and industries with traded and untraded agglomeration externalities. Its main core is the maximization of opportunities for face-to-face meetings, which make it possible the exchange of tacit knowledge contributing to sustainable growth, jobs, and social cohesion (DCMS 2001, 2013; Florida 2002, 2005; Scott 2006; Pratt 2008; European Commission 2017).

[3] The sharing economy is an economic system that enables a shift away from a culture where consumer's own assets, toward a culture where consumers share access to assets. This shift is driven by internet peer-to-peer platforms which will disrupt the unsustainable practices of hyper-consumption that drive capitalist economies (Botsman and Rogers 2011; Martin 2015).

[4] See, for instance, the following papers for alternative definitions of CWS: Lange (2011), Spinuzzi (2012); Capdevila (2014), Moriset (2014), Merkel (2014) or Mariotti et al. (2017).

community and its knowledge sharing dynamics. On the basis of the aim of this paper, but, we understand CWS as in Mariotti et al. (2017) do (see footnote 1).

The increasing importance of CWS has been reflected in an increase in the number of publications in various areas of study (Gandini 2015). Most contributions come from different disciplines such as Sociology (Gandini 2015; Parrino 2015), Geography (Moriset 2014), Business and Management (Capdevila 2013, 2014) and Economics (Deijl 2014). However, to our knowledge few studies have focused on the location patterns of CWS. Among the few contributions that have been made taking into account this issue, most authors suggest that CWS are expanding globally in most advanced economies, but they are clearly an urban phenomena (Moriset 2014, Merkel 2014; Chuah 2016; Mariotti et al. 2017).

Beyond the CWS tendency to locate in urban areas, specially, the so-called 'creative cities' – such as San Francisco, London, Paris, Amsterdam or Barcelona – are those hosting the largest number of CWS (Cushman & Wakefield 2018; Deskmag 2018). According to Moriset (2014), the abundance of CWS in a given city can be explained by the kind of urban liveliness and vibrancy that makes a place fashionable and attractive for artists, "bohemians", and entrepreneurs in high-tech and cultural content industries. Moreover, in most cases CWS supply mostly responds to the creative and knowledge workers needs in the aforementioned socioeconomic context. Besides that, urban policies have focused on providing and improving cultural and urban amenities to attract the most creative and high-skilled workers. Thus, the location of CWS may be, to a great extent, associated to that of CIs and creative professionals. Actually, CIs are concentrated in localised clusters rather than dispersed throughout metropolitan areas (Boix et al. 2015; Coll-Martínez et al. 2018). We could therefore expect to find a clear agglomeration of CWS at very short distances. Indeed, given the clear relationship between CIs and CWS, we therefore could expect to find a clear coagglomeration between CWS and CIs firms. Also, these results may change depending on the dominant knowledge base in each creative sector.[5]

Regarding the main location factors of CWS, Capdevila (2014) claims that most CWS are start-ups with a single location founded by entrepreneurs that live in the same district and,

[5] There are three definitions of knowledge base for innovative and creative activities – analytical, synthetic and symbolic – which are defined according to a mixture of tacit and codified knowledge, the possibilities and limitations of knowledge codification, and the competences and skills required for the development of their activity (Asheim et al. 2007; Asheim and Hansen 2009).

that those professionals who decide to join a CWS often look for a "third place" (Oldenburg 2002), between home and work, away from the distractions of home and with a social atmosphere. In this regard, Merkel (2014) argues that the city provides CWS by the urban amenities and creative and entrepreneurial milieu that facilitate the knowledge exchange and production. Also Chuah (2016), who provides a qualitative analysis on CWS location in New York City, suggests that the public provision of neighbourhood services and amenities are key factors to foster the potential of CWS in the urban context. Mariotti et al. (2017) found that the location of CWS in the core of Milan may be explained by a high urban density in terms of firms and population, the good local public transport accessibility, skilled labour force availability as well as the proximity to universities and research centres.

To understand the location patterns of CWS, it is also worth noting that CWS can be provided by a diverse range of institutions such as a firm, a public institution (e.g. chamber of commerce or library (Bilanszic and Foth 2013), a university (Bouncken 2016), or a company (e.g., Google or Microsoft). Indeed, we can find public, semi-private-public and private types of ownership or governance structures. Public CWS offer a membership open to everyone, semi-public-private CWS can restrict the access to infrastructure and social structure and may require employee status, while private CWS are thought to foster creativity and the development of new projects and ideas with a return to the firm who controls the CWS (Bouncken and Reuschl 2018). Thus, the location decision of CWS should change according the type of provider. Nevertheless, and as Moriset (2014) noticed, even big firms and corporations, who are investing on CWS projects, are looking for open office spaces in main city centres or some neighbourhoods providing the facilities and infrastructures to facilitate their work as well as the proximity to the urban buzz of the city centre (i.e., the Paris Silicon *Sentier* in Paris or the 22@ district in Barcelona). In this regard, it seems that the location of CWS may be to some extent explained by the entrepreneurial environment in their surroundings.

All in all, we could therefore expect to find a coagglomeration of CWS with specific kinds of firms, and this coagglomeration may change according their size. On the one hand, this coagglomeration should be more intense between smaller firms since they have a greater need for concentration to gain access to other services and lower transaction costs compared to larger firms (Scott 1988). Indeed, for the case of CIs this should be even more

important due to the high levels of uncertainty, instability and flexibility to adapt to new projects (Scott et al. 2001; Asheim et al. 2007; Pareja-Eastaway 2016). On the other hand, the coagglemeration between CWS and larger firms may be also intense because of the interest that big companies in creative and high-tech industries may have on being connected to local entrepreneurial ecosystems and get flexible access to talents and skills, as well as, to keep an eye on creative initiatives and start-ups (Malecki 2001).

3. DATA AND METHODOLOGY

3.1. Study area and Data

The study area of this paper is the city of Barcelona, the second largest city in Spain with more than 1.6 million inhabitants (2017). The city is delimited by the sea in the east and by a mountain range in the west, covering an area of 101.4Km^2. The city is divided in 10 districts and 73 neighbourhoods (see figure 1).

[INSERT FIGURE 1]

The main reasons to focus on Barcelona, apart from those mentioned in section 1, is the large number of CWS in the city, being the city with the highest density of CWS in Europe (Capdevila and Zarlenga 2015).

The data of this paper comes from different sources (see table 1). Data about CWS comes from *Creative Catalonia*, *Cowocat* and *Barcelona Navigator*, which are public agencies that collect data from CWS, as well as data from start-ups and creative firms in Catalonia. Our dataset contains 148 CWS in the city of Barcelona. In this case we collected data about the CWS location (latitude and longitude) in order to measure the agglomeration and coagglomeration of CWS with Creative industries. We control for the data about Creative firms come from SABI database, which provides information about more than 2 Million Spanish and Portuguese firms[6]. Finally, the data related to the city of Barcelona (i.e. amenities and public information about the city) comes from the Barcelona Statistical Service and Open Data Barcelona, both public statistical services provided by the Barcelona city council.

[6] SABI database include several firms' characteristics including year of entry, balance sheets, income, expenditure accounts, number of employees, industry, sales, assets, and georeferenced location (i.e., X-Y coordinates). SABI collects data from the Mercantile Register, where all limited liability companies and corporations are obliged by law to deposit their balance sheets. This is the most widely used dataset in Spain and Portugal when firm georeferenciation is required and it is provided by Bureau Van Dijk.

[INSERT TABLE 1]

Our final dataset has 148 CWS on the city of Barcelona in 2017 and 4654 Barcelona Creative firms in the same year, sorted by type of industry, Knowledge and size (see table A1 in the annex) and a set of Barcelona city variables at neighbourhood level in 2015[7].

3.2. Methodology

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. Let us define an industry S with n firms, then we compute a circle distance (i.e., radius) between each pair of firms in that industry, obtaining $n(n-1)/2$ bilateral distances for industry *S*. We denote 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:

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

, where *h* is the optimal bandwidth, and *f* is a Gaussian kernel function, where all densities are calculated. It's relevant to mention that an employment-weighted version of the K-density exists, but in this paper we are not using it because our research question, which focuses on the agglomeration and coagglomeration of the CWS and Creative firms inside the city of Barcelona only considers the establishment location and it is not necessary to assign a weight to each point.

This function will be used at intra industry 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 with an average simulated value (whole economic activity) under the null hypothesis of same density value that the average simulated value for each distance. 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 for the case of Canada or Méndez-Ortega and Arauzo-Carod 2018, for the case of Barcelona).

[7] The reason to use 2015 variables is the lack of data available for recent years. See table A2 for a descriptive statistics of the variables.

4. RESULTS

4.1. Location patterns

In this section we will discuss which is the location pattern of CWS in the city of Barcelona and the correlation of this spaces with some city variables. In the table 2 we present a correlation of CWS with some variables at neighbourhood level.

[INSERT TABLE 2]

Apparently, it seems that the number of CWS is positive and statistically significant correlated with transport amenities (Bike services and Metro stations), high income neighborhoods, places with high rents and with a high proportion of office spaces and foreign people, while this correlation is negative and statistically significant with the distance to *Plaça Catalunya*, the cultural and creative spot of Barcelona.

[INSERT FIGURE 2]

These results highlight the importance of accessibility for these spaces, one of the most sought after characteristics by firms who need this type of space. CWS are mostly located in high-income neighbourhoods with high rents, high proportion of offices and close to *Plaça Catalunya*. These jointly with Figure 2 indicates that CWS seek to be located in the CBD, an area with high business density, good amenities and transport and where due to that, rents are very high[8]. This makes the CWS ideal spaces for firms with few resources, since they offer an optimal location at affordable prices. This firm's profile fits with CIs firms, since it is a type of firm which require high-skilled human capital, they are mostly small and in the beginning of their economic activity and most of them have few resources (Pareja-Eastaway 2016; Mariotti et al. 2017).

4.2. Agglomeration and Coagglomeration of CWS

In this section we show the Kd function of the CWS for the city of Barcelona and the relationship between these spaces and CIs firms (by size, type of knowledge and type of industry) and Non-creative firms[9].

[8] The Central Business District (CBD) of Barcelona includes Diagonal Avenue and *Passeig de Gràcia* until *Plaça Catalunya*.

[9] All calculations use a 0.05 significance level, using 1000 simulations. The dashed line corresponds to the

[INSERT FIGURE 3]

Figure 3 shows the agglomeration of CWS and its coagglomeration with Creative and non-Creative firms at city level. At first glance it is observed that there is a high agglomeration of CWS in the first tram of the ratio (up to 4,000 meters). This result suggests that there is a high agglomeration of CWS and this concentration is statistically significant but this agglomeration rapidly disappears when distance increases. Also we observed that there is a clear coagglomeration between CIs and CWS, while this coagglomeration is not observed with non-creative firms. This result shows that CWS are clearly co-agglomerated with CIs, since CWS provide a diverse space with liveness and vibrancy, which makes a place fashionable and attractive for creative entrepreneurs and "bohemians" (Moriset 2014).

[INSERT FIGURE 4]

Figure 4 show the coagglomeration of CWS with different creative firm's size[10]. It seems that there is a coagglomeration between CWS and small and large creative firms and this coagglomeration rapidly decrease with distance (up to 4,000 meters approximately). Apparently, there is no coagglomeration of CWS with medium creative firms. These results suggest that there is an attraction between CWS and large and small creative firms, this attraction with small firms can be explained due to their need of access to some services provided by CWS and then, reduce transaction costs (Scott 1988). In the case of large creative firms, their coagglomeration with CWS could be explained by the need of being connected to local entrepreneurial ecosystems and get flexible access and low transaction costs to skill workers and to analyse how star-ups or creative initiatives are going (Malecki 2001).

[INSERT FIGURE 5]

Figure 5 presents the coagglomeration of CWS with creative firms by type of knowledge. We observed that CWS tend to co-agglomerate with Symbolic and Synthetic CIs firms at the first tram of the radius and, as in the previous cases, this coagglomeration rapidly decreases with distance (up to 4,000 meters for CWS with Symbolic Creative firms and up to 3,000 meters for CWS with Synthetic Creative firms). There is no coagglomeration of CWS with Analytical Creative firms, possibly because they are less need of tacit interaction and specific environments than Symbolic and Synthetic-base Creative firms.

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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.

[10] The classification of firm size is small (less than 50 employees), medium (less than 250) and large (250 or more).

[INSERT TABLE 3]

Finally, table 3 summarizes the Kd function of CWS with CIs firms by type of sectors. This table allows us to differentiate among sectors and to see if there is a spatial coagglomeration or dispersion of these sectors with CWS. At first glance it is observed that Software, Audiovisual, Broadcasting, Advertising, Design and Arts are industries co-agglomerated with CWS at the first stretch of the radius, and this agglomeration decreases with distance. In the case Heritage, Photography, Social R&D, Natural R&D, Architecture and Engineering and Videogames are sectors were there are not significant coagglomeration or dispersion with CWS. This result suggests that for the coagglomeration sectors, there is mutual interest in locating nearby, since these are sectors that share the type of worker that can be found in a CWS. However, for sectors as Photography or Heritage, this interaction does not exist.

To sum up, these results suggest that there is a coagglomeration between CWS and Creative firms, but this agglomeration differ among firm size, type of knowledge or type of sector.

5. CONCLUSIONS

The main aim of this paper was to identify and explain the location patterns of co-working spaces (CWS) in the city of Barcelona. With this paper we therefore contribute to the literature on CWS by providing an intra-city analysis of agglomeration and coagglomeration of CWS with the creative industries (CIs). We deal with previous methodological limitations by making use, for the first time in this literature, of geographical information systems and the Kd-function of agglomeration and coagglomeration (Duranton and Overman 2005; 2008) in the analysis of location patterns of CWS. Specifically, our results suggest that i) CWS are highly concentrated in the most central areas of Barcelona, ii) CWS are significantly agglomerated at short distances and this agglomeration rapidly disappears when distance increases, iii) there is a clear coagglomeration between CWS and CIs firms (specifically, with symbolic and synthetic-based CIs firms), and iv) there is not significant coagglomeration with non-CIs.

These results confirm our preliminary expectations and complement previous contributions. Specifically, they endorse the theoretical discourse on that CWS find clear advanges on agglomerating in urban cores (Moriset 2014; Merkel 2014). Moreover, they

complement the findings of Mariotti et al. (2017), which until now was the only study to analyse the location patterns of CWS within the city, but for the case of Milan. We also found that CWS are highly clustered around two focal points in Barcelona city centre. However, by taking advantage of GIS and the Kd-function to test the statistical significance of the results at each distance, we are also able to ascertain what the urban factors that may influence their location decision are, as well as, to discern any potential interdependencies between CWS and specific kinds of economic activities within the city.

From the literature and our findings, it is possible to raise some questions for further discussion. Fist, given that CWS are highly agglomerated in the city centre, we wonder whether the agglomeration of CWS is at the end a matter of increasing office rent prices in the city centre than building social connections and strong horizontal networks that facilitate connections across professional and residents and public sector actors is stressed in this literature (Stern and Seifert, 2010; Capdevila 2014; Borrup, 2015; Brown 2017). Second, taking into account the clear trend towards spatial concentration of CWS in the city centre given the increasing attractiveness of these areas for specific groups of workers and the potential benefits for real estate owners to rent their properties as CWS instead of the traditional residential renting letting option, it seems clear that a growing supply of these spaces may arise in the city centre in the following years. Unfortunately, this fact also implies some risks related to a potential coworking "bubble" and real estate speculation (Moriset, 2014) as it has already happened for the case of the tourist apartments in the city, leading to increasing housing and office prices, gentrification or increasing inequalities in the core neighbourhoods of big cities.

Despite all these facts, the paper does have some limitations. In this regard, any future research will expand this analysis in two main ways. Firstly, the period of analysis should be expanded in order to check for time dynamics on the location patterns of CWS. Secondly, we will explain their location decision by estimating their creation as a function of the aforementioned urban characteristics. To do so, access to information about their size and characteristics will be necessary, as their location decision may vary according to them.

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TABLES

Table 1. Description of the variables.

Variable	Description	Source
CWS	Number of Co-working Spaces (2017).	Creative Catalonia, Cowocat & Barcelona Navigator
Bike	No. of public bike service stations (2015).	OD-BCN
Uni	No. of Faculties, Business Schools and Research centres (2015).	OD-BCN
MTS	No. of Metro and Train lines (2015).	OD-BCN
Income	Income index (Barcelona=100) (2015).	BSS
Park	Park surface (in ha) (2015).	OD-BCN
Rent	Rent price (2015).	BSS
Den_pop	Population density (2015).	BSS
Dist_pc	Euclidean distance to *Plaça Catalunya.*	OE
Prop_ofi	Proportion of Office Space (2015).	OD-BCN
Pop_ext	Proportion of Foreign people (2015).	OD-BCN
Creative firms	Number and location of Creative firms (2017).	SABI

Source: Authors. Note: OD-BCN (Open Data Barcelona), BSS (Barcelona Statistical Service), OE (Own Elaboration). All these variables are at neighbourhood level.

Table 2. Correlation matrix of CWS with some variables at neighborhood level.

Variable	Correlation with CWS
Bike	0.714***
	(0.000)
Uni	0.156
	(0.188)
Metro	0.452***
	(0.000)
Income	0.375***
	(0.001)
Park	-0.183
	(0.000)
Rent	0.332***
	(0.004)
Den_pop	-0.085
	(0.474)
Dist_pc	-0.531***
	(0.000)
Prop_ofi	0.721***
	(0.000)
Prop_ext	0.401***
	(0.000)

Source: Authors. Note: *** p<0.01, ** p<0.05, * p<0.1 (Significance at 1, 5 and 10 % respectively).

Table 3. *Kd* Function CWS vs. Creative Sectors.

	0-1000m	1000-2500m	2500-5000m	5000-20000m
Videogames	*NS*	*NS*	*NS*	*NS*
Software	*SOA*	*OA*	*SOA*	*NS*
Arch. & Eng.	*NS*	*SOA*	*SOA*	*SD*
Natural R&D	*NS*	*NS*	*SOA*	*NS*
Social R&D	*NS*	*NS*	*SOA*	*NS*
Audiovisual	*OA*	*OA*	*SOA*	*D*
Broadcasting	*OA*	*OA*	*SOA*	*D*
Advertising	*OA*	*OA*	*SOA*	*D*
Design	*SOA*	*OA*	*NS*	*SD*
Photography	*NS*	*NS*	*SOA*	*NS*
Arts	*OA*	*OA*	*SOA*	*D*
Heritage	*NS*	*NS*	*NS*	*NS*

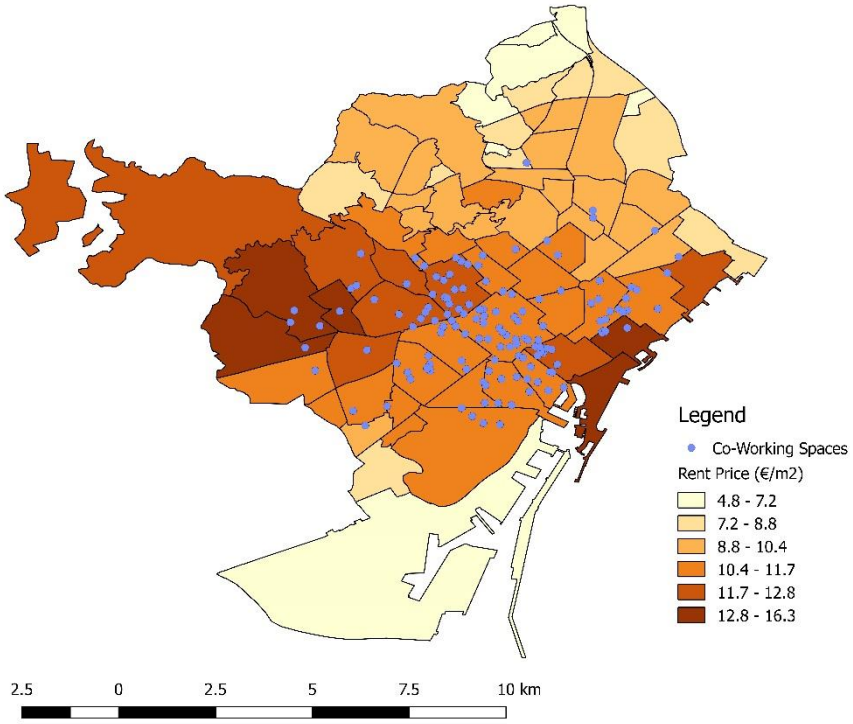
Source: Authors. Note: *NS* (Not significant), *OA* (Over co-Agglomeration), *SOA* (Slightly Over co-Agglomeration), *D* (Dispersion), *SD* (Slightly Dispersion).

FIGURES:

Figure 1. City of Barcelona by neighborhoods (73)

Source: Barcelona Statistics Service (www.bcn.cat/estadistica)

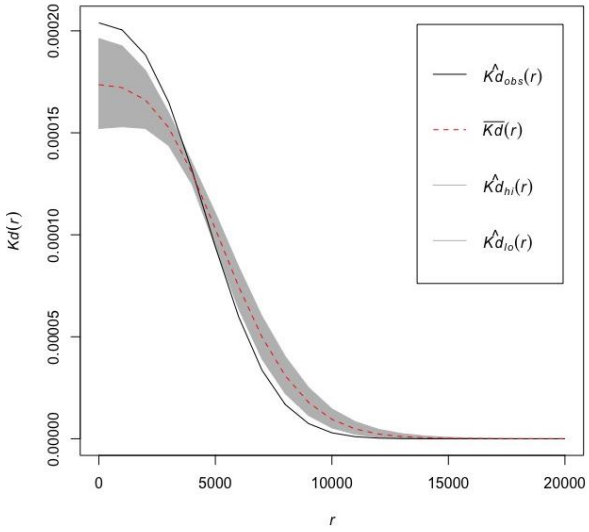
Figure 2. CWS and rent prices by neighbourhood in Barcelona



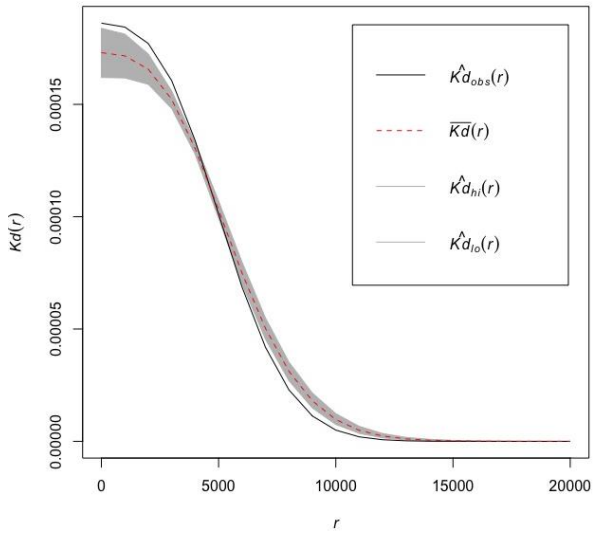
Source: Authors

Figure 3. *Kd* function of CWS and co-location with creative and non-creative firms.

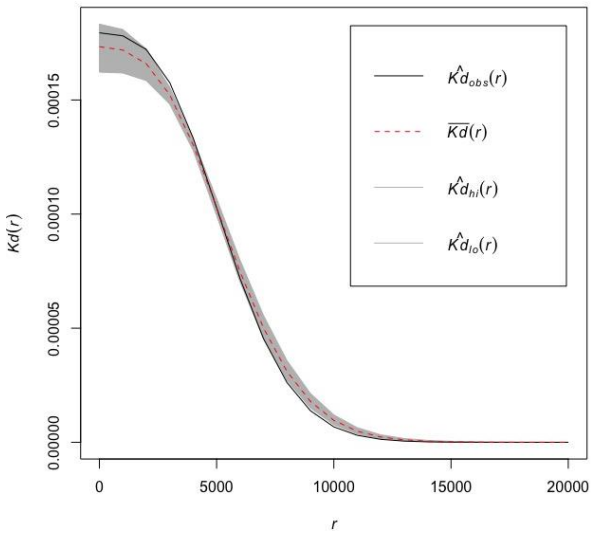
Intra-industry CWS



CWS vs. Creative firms

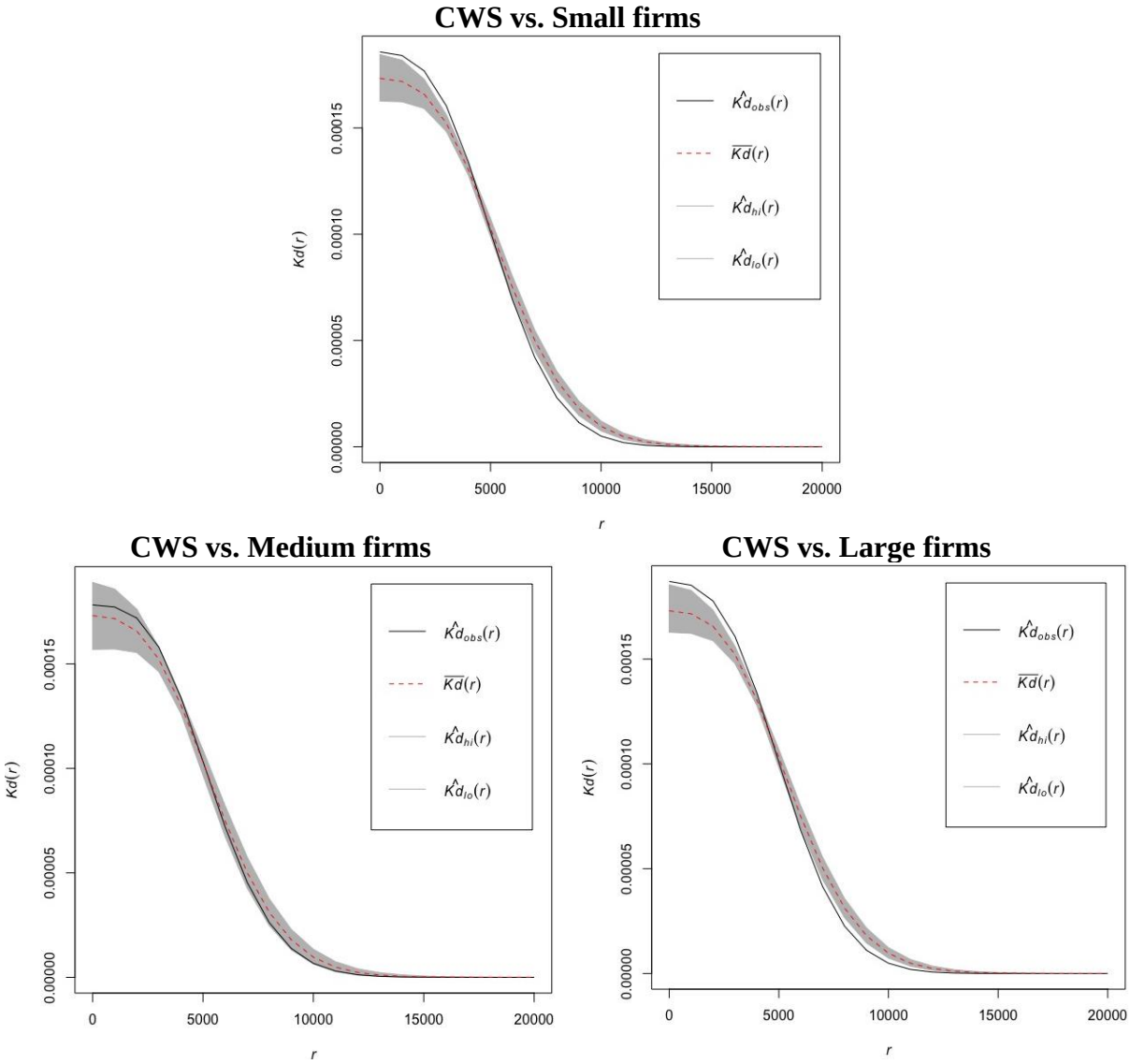


CWS vs. Non-Creative firms



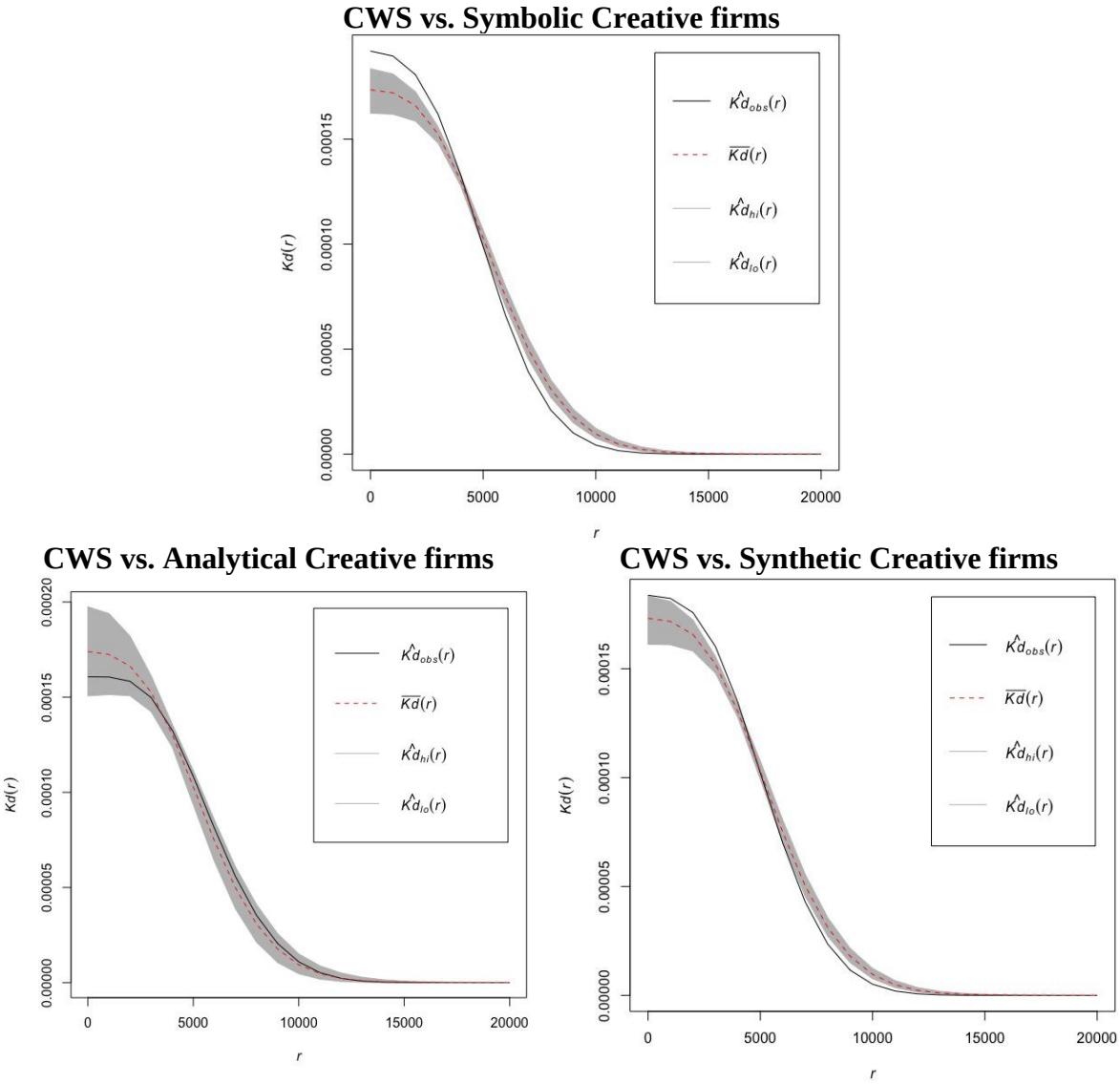
Horizontal axis units (r): meters. Source: Authors

Figure 4. *Kd* function of CWS with creative firms by size.



Horizontal axis units (r): meters. Source: Authors

Figure 5. *Kd* function of CWS with creative firms by type of knowledge.



Horizontal axis units (r): meters. Source: Authors

APPENDIX

A1. Number of Creative and non-Creative firms by type, size, knowledge and sector.

Creative firms			
by size		**by type of knowledge**	
small	2554	Analytical	112
medium	107	Symbolic	2547
large	1993	Synthetic	1707
Total	**4654**	**Total**	**4366**
by sectors			
Advertising	1108	Natural R&D	78
Arch&Eng	1140	Photograph	108
Arts	231	Publishing	401
Audiovisual	403	Social R&D	34
Broadcasting	51	Software	560
Design	226	Videogames	7
Heritage	19	**Total**	**4366**
non-Creative firms			
Total		**37684**	

Source: Authors

A2. Descriptive statistics of variables.

Variable	Mean	Standard Deviation	Max	Min	Range	Median
CWS	2.027	4.336	29	0	29	0
BIKE	6.192	6.981	34	0	34	4
UNI	0.808	1.838	11	0	11	0
MTS	91.49	60.22	320	8	312	77
Income	92.30	43.84	250.5	34.50	216	83.20
Park	0.145	0.109	0.476	0.009	0.466	0.121
Rent	10.27	2.111	16.33	4.780	11.55	10.31
DEN POP	675.5	293.4	1496	31.31	1464	702.0
dist pc	4244	1944	8779	697.7	8082	4206
Prop ofi	1.579	1.965	11.40	0	11.40	0.900
Prop ext	5.314	1.998	14.22	1.802	12.42	4.859

Source: Authors