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Agglomeration of Creative Industries: an Intra-metropolitan Analysis for Barcelona

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# Agglomeration of Creative Industries:
# An Intra-metropolitan Analysis for Barcelona*

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**Abstract:**

The aim of this paper is to analyse the spatial patterns of agglomeration and coagglomeration of Creative Industries (CIs) in the Metropolitan Area of Barcelona (MAB). We compare agglomeration patterns of CIs to non-creative ones (Non-CIs) in order to identify specificities in their location patterns at an intra-metropolitan level. We use firms' geo-located data for 2012 to calculate the distance-based *M* and *m* cumulative and density functions of agglomeration and coagglomeration. Our main results show that CIs and Non-CIs have different agglomeration patterns. Concretely, whilst CIs tend to cluster at very small distances, Non-CIs have a more dispersed pattern. Concerning the results of coagglomeration, these reveal that micro CIs and Non-CIs seem to be coagglomerated. Regarding agglomeration patterns of subgroups of CIs, we find that these sectors display high levels of agglomeration individually, and that there is a clear coagglomeration among them in the MAB. Finally, our results emphasise Barcelona's centre as a magnet for Cultural and CIs.

*Keywords: creative industries, agglomeration, M function, intra-metropolitan analysis, Barcelona*

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## 1. Introduction

Creative Industries (CIs) are a range of economic activities that use creativity as main input and that provide tangible and intangible products or services with creative content and economic value. These industries are nowadays a topic of increasing interest since they seem to contribute to local economic growth, development, competitiveness and productivity (DCMS 2001, UNCTAD 2010, Boix and Soler 2015). According to UNDP (2013), these industries are one of the most rapidly growing sectors of the world economy. This can be explained by the need for restructuring the economic activity in order to be more competitive in an increasingly global world. In this context, the uncertainty of continuous technological changes requires governments to redirect their economies and societies to creativity. The increasing importance of the CIs has been reflected in a boost in the number of publications in various areas concerning their study (see for example, O'Connor 2010). One of the main topics of interest in the literature of CIs is clustering (see for instance, De Propris et al. 2009a, Lazzeretti et al. 2012b, and Cruz and Teixeira 2015); however, it is difficult to define a clear pattern of agglomeration of CIs due to the use of different definitions of creative clusters and methodologies, and the variety of geographical areas and sectors analysed.

In this paper, firstly we aim to provide an extensive intra-metropolitan analysis of the intensity and extent of the agglomeration and coagglomeration of CIs within the Metropolitan Area of Barcelona (MAB) which seems to be quite important in the CIs' context due to their tacit and symbolic knowledge base. Secondly, we test whether agglomeration patterns of CIs differ from those of non-creative industries (Non-CIs), and also if these patterns change across specific subgroups of CIs. Additionally, we examine whether different CIs coagglomerate. Then, in order to deal with previous methodological limitations, we use geo-referenced data from the SABI database (Bureau van Dijk) for the year 2012 at three digits NACE code for the MAB to calculate the relative distance-based *M* and *m* cumulative and density functions of agglomeration and coagglomeration (Marcon and Puech 2010; Lang et al. 2015). Ours is the first paper to use these two complementary distance-based measures to analyse agglomeration patterns of creative firms. Both functions compare the location patterns of an economic sector to that of the aggregate economic activity. By building counterfactual location simulations, we can establish whether the observed agglomeration is statistically significant at each distance. The *M* function provides information on the strenght and significance of agglomeration and coagglomeration up to a certain distance, while the *m* relative function provides this information at a given distance.

We focus on the MAB which is one the largest metropolitan areas of the European Union in terms of creative workers. Concretely, in 2012 there were more than 100,000 creative workers representing more than 10% of total employment only in Barcelona. From 2001 to 2012 the number of creative workers has increased in relative terms even the crisis (Ajuntament de Barcelona and IERMB 2013). The relevance of CIs in the metropolitan area is due to the process of transformation of Barcelona into an economy oriented to innovation, creativity and culture in which it is involved since the nineties. The main aim of implemented policies and strategies is to even further establish Barcelona as one of the most important centres for creative and knowledge activities.

Still the relevance of Barcelona, there is little evidence about the agglomeration of CIs within the area. Even so, two main contributions stand out. First, Boix et al. (2013b) provide an interesting descriptive analysis of the location of CIs around Barcelona in 2011 by using some mapping tools. The second work that we highlight is Boix et al. (2014), whose aim is to explain and identify geographic boundaries of creative clusters in Europe by applying a geo-statistical algorithm to a continuous space. Due to this is the only contribution, to the best of our knowledge, analysing agglomeration and coagglomeration of CIs from a continuous space point of view, it will be interesting to compare our results to their findings on the Barcelona's case.

Our main results show that CIs and Non-CIs have different agglomeration patterns. Concretely, CIs tend to be more clustered at very small distances (with a significant *M*-peak of 2.5 up to 1 km).Thus, our results are in accordance to previous theoretical discourses (Scott 1996), but ours are the first ones to empirically test it. Concerning the results of coagglomeration, these reveal that Non-CIs do not seem to cluster around CIs, but CIs do slightly concentrate around Non-CIs. However, when we calculate the *M* functions for those firms with less than 10 workers, we do find a clear coagglomeration between CIs and Non-CIs. Regarding agglomeration patterns of subgroups of CIs, these sectors present high levels of agglomeration individually. Also we find clear coagglomeration among several creative sectors. Indeed, when the *m* function is applied to each creative sector, results confirm that there is a centralised agglomeration of those CIs strongly based on place image and symbolic knowledge in Barcelona centre and, particularly, in some neighbourhoods. These results highlight how CIs have strong specificities in terms of their location patterns compared to the whole range of activities and that they benefit from clustering on particular zones (neighbourhoods) within the city where they easily find networks among creative disciplines, soft characteristics, and also place-specific image.

We have structured this paper as follows. In Section 2 we review the literature on the measurement of agglomeration economies and geographic concentration of economic activities focusing on the state of the art for CIs. In Section 3 we present the data. In Section 4 we present and discuss main results. Finally, in Section 5 we draw main conclusions and discuss some policy implications.

## 2. Literature Review

In this section, first we introduce the concept and measurement of agglomeration economies and, then we expose the problems concerning traditional methods of their measurement and present an alternative method. Finally, we review the most relevant studies analysing the agglomeration patterns of CIs.

*2.1 The concept and measurement of agglomeration*

The idea of agglomeration economies (those benefits derived from the spatial concentration of jobs and firms) was firstly introduced by Marshall (1920), who also identified their sources: specialised labour markets, availability of suppliers and knowledge spillovers. Later, these agglomeration economies were subdivided into localisation and urbanisation economies by Hoover (1936). The former are those advantages arosen from the spatial concentration of similar activities while the latter come from the concentration of non-related activities. Moreover, it is also possible to differentiate sources of agglomeration economies at inter-regional and intra-metropolitan level. According to Rosenthal and Strange (2001, p.193), agglomeration economies benefit larger from knowledge spillovers at smaller geographic scales (i.e. cities, districts, etc.), from availability of inputs and resources at larger geographic scales (i.e., regions or states), and specialised pools of labour impacting at all geographic levels. Then, policies aiming to favour the agglomeration of economic activities may differ among geographic levels.

After the emergence of these concepts, there have been studies proposing ways to appropriately measure the geographic concentration of economic activities, such as Ellison and Glaeser (1997), Rosenthal and Strange (2003), Duranton and Overman (2005; 2008) and Puga (2010), among others. Some of these studies use area-based methods (i.e., Ellison and Gleaser Index, Gini Index, etc.), which involve several problems such as the MAUP.[1] These problems can be mainly solved by using distance-based methods (Duranton and Overman 2005; Marcon and Puech 2010; Espa et al. 2013, among others).[2] In fact, some years ago the application of distance-based methods were more complex than nowadays as the accessibility to microgeographic data was constrained. Even so, it is possible to find some contributions analysing the spatial distribution of manufacturing firms using distance-based methods (Chakravorty et al. 2005; Deurloo and De Vos 2008; Arbia et al. 2014; Moreno-Monroy and Garcia 2015, Behrens and Bugna 2015, among others).

[1] The MAUP appears when the same analysis is applied to the same data, but different aggregation schemes are used, involving different results. MAUP takes two forms: the scale effect and the zone effect. The scale effect exhibits different results when the same analysis is applied to the same data, but changes the scale of the aggregation units. The zone effect is observed when the scale of analysis is fixed, but the shape of the aggregation units is changed. See Arbia (2001) for more details.

[2] To know more about these problems and methodologies see Section B of the Appendix.

Conversely, there is little evidence of this phenomenon in the case of CIs clusters. Among the ones that have tried to analyse them, they use area-based methods of measurement of agglomeration and most of them merely are descriptive analysis of the presence of CIs in different cities or regions. Most studies tend to work with indices of spatial concentration (e.g. location quotients) as in Scott (2000), De Propris et al. (2009a), Lazzeretti et al. (2012b), and Cruz and Teixeira (2015) in the EU's context. And for the North-American case, we find the contributions of Currid (2006), Catungal et al. (2009), Currid and Williams (2010), among others which also use these indices and hotspots mapping tools. Broadly speaking, most of these studies show that agglomeration of CIs can be mainly explained by urbanisation economies, and find that these industries tend to cluster in industrial districts and cities or metropolitan areas due to their intrinsic characteristics (i.e. networking facilities, the presence of cultural infraestructures and amenities, proximity to political power, availability of larger consumer markets, etc., which are easier to find in those places).

Alternatively, Boix et al. (2014) apply a geo-statistical algorithm to a continuous space for some European countries, showing that CIs are highly clustered and coagglomerated in large metropolitan european areas. Even if Boix et al.'s methodology allows to analyse this phenomenon at inter-metropolitan and intra-metropolitan levels in Europe, it could be also interesting to examine the extent and intensity of this agglomeration at a more detailed scope within those large metropolitan areas, such as Barcelona.

### *2.2 What explains CIs agglomeration?*

Traditional factors explaining the creation of industrial clusters formally suggested by Marshall (1920) can also be applied to agglomeration of CIs. In this sense, CIs may benefit from localisation economies and urbanisation economies.[3]

Regarding the former, CIs may cluster to take advantage of the existence of local knowledge spillovers, as they strongly depend on tacit knowledge which in their context have been defined as 'creative atmosphere' (interaction among social, economic and cultural agents); to benefit from pooled specialised labour markets, as managers of creative projects could easily find the skills they require and, at the same time, creative workers enjoy a greater job stability; and the availability of local suppliers specialised in other parts of the creative *filière*, due to their flexible nature they take profit from choosing the adequate specialised partner (Landry 2000; Florida 2002; Maskell and Lorenzen 2004; Scott 2006; Santagata and Bertacchini 2011).

[3] See Branzanti (2014) for a survey of studies focusing on district economies in the context of CIs.

So, even the short-term nature of CIs' projects (as film or performing arts industries), creative activities need to be near each others in order to find those professionals with the most appropiate skills and experience when they just require them. At the same time, if those project managers are satisfied with their work, they will contract them regularly involving a certain stability for those creative workers. This "stability" benefits most creative workers, as many of those are engaged in part-time, temporary and freelance forms of work even within groups of high-wage workers.

Thus, considering that CIs have a great need for spatial proximity in order to take advantage of these face-to-face interactions among creative agents, high agglomeration of CIs at small distances and a rapid distance decay of this agglomeration are expected.

About urbanisation economies, CIs take advantage from the capacity of local consumption markets and from the diversity of activities and people (Lorenzen and Frederiksen 2008; Lazzeretti et al. 2012b). At the same time, demand-side factors should be considered as well. In this sense, CIs might cluster in large urban areas to take advantage of the proximity to larger concentrations of consumers as well as a wider range of consumer preferences, and higher levels of income per capita (Turok 2003; Heilbrun 1996).

Despite the significant role of localisation and urbanisation economies, when analysing the agglomeration of CIs at an intra-metropolitan level we should give more relevance to one of the key factors explainig this agglomeration, that is their dominant knowlegde base. CIs are associated mainly to symbolic knowledge.[4] As this industry relies mainly on tacit interaction between creative and cultural agents (face-to-face) and on the specific environment of the area where they operate, some authors argue that CIs are highly sensitive to distance-decay which involve that they tend to be highly concentrated in space (Boix et al. 2014). This is also the reason why CIs are supposed to be clustered in a more obvious way than non-creative manufacturing activities (Scott 1996). Thus, we could expect to find a higher intensity of agglomeration and a more rapid distance decay of this agglomeration for CIs than for any other industry with a similar firm-size distribution.

Even if these theories can contribute to explain the spatial concentration of CIs, some authors argue that they give only a partial explanation on the determinants of location of CIs (Tschang and Vang 2008). In this sense, CIs may agglomerate because of the mere presence of amenities and specific institutions and infraestractures. Among them, the existence of historical and cultural

[4] In the literature we can find three different definitions of knowledge bases for innovative and creative activities: analytical, synthetic and symbolic. All of them are defined according the 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. See Asheim and Parrilli (2009, 2012) for more details.

infraestructures which are essential sources of inspiration for creative workers; infrastructure of specialised public and social actors providing support to these activities (e.g., education and training institutions, government funded agencies and private lobbying organisations); 'soft characteristics' or amenities in terms of quality of life, tolerance, cosmopolitan environments; a particular identity o place image also facilitates the attraction of creative talents and entrepreneurs pursuing a particular life style (Scott 2000; Andersson and Andersson 2008; Pareja et al. 2008; Murphy et al. 2014; Coll-Martínez and Arauzo-Carod 2015).

However, when an intra-metropolitan analysis of the agglomeration of CIs is conducted, we should consider that, in fact, there is an heterogenuous distribution of amenities and cultural infraestructures across neighbourhoods within the city (Currid and Williams 2009, p. 425). In this sense, if CIs are mainly attracted to those well-located neighbourhoods where things happen (i.e. social and networking events), we could expect to find creative activities highly agglomerated in some locations of the city, and a rapid decay of this agglomeration once we move away from these focal points. That is, when we zoom in on neighbourhoods within the city, we should see how some CIs tend to be located in the same streets or neighbourhoods because of the *allure,* cultural interest and networking possibilities of these places.

Let's give an example. Imagine that you were an illustrator or a writer, so you would be interested in being on that neighbourhood where you can find those services (i.e. specialised shops, public institutions), partners (other creative workers or enterprises), activities (i.e. opening events, awards ceremonies), and amenities (i.e. museums, galleries, coffee shops) that facilitate and inspire your work and, at the same time, the creation of a network of professional contacts.

At the same time, but, the increasing attraction of these trending (hipster) neighbourhoods could involve the dispersion of creative activities to some extent. That is, once these neighbourhoods increase their popularity due to all the advantages their offer, the rise of rental prices as well as those of other services are expected for these areas. As a result, some CIs activities may decide to locate in other areas where life and activity costs are more affordable. Moreover, the possibility of teleworking nowadays is more feasible than ever before due to the advances in information technology systems. So, those creative workers with a self-employment and freelance nature could have their headquarters in Barcelona but they could work from home.

Having in mind all these hypothesis, we will try to find out whether those forces inducing to agglomeration of CIs are greater than dispersing ones.

*2.3 What explains CIs coagglomeration?*

Coagglomeration patterns of CIs have not been broadly analysed. A number of studies that have tried to do so conduct mainly descriptive analysis by using Geographical Informations Systems (GIS) (Currid and Williams 2010), correlation techniques (De Propris et al. 2009a), or discursive approaches (Scott 2000; Moomas 2004; Pratt 2011). All these studies have found that several CIs colocate in the same cities and that they have located close to each others due to similarities in terms of infraestructes and social and economic networks they require to operate.

However, the use of these traditional methods could not be enough to test whether there is actually coagglomeration of CIs or not. Actually, by simply observing whether a couple of industries tend to locate together does not say anything about potential linkages among them or about the reasons explaining that decision. In fact, there is the possibility that the coagglomeration of CIs may be explained simply by the same reasons inducing the location of service activities in urban areas, that is, those areas are a focal point where accessibility is easier to many people, so in them firms have access to a greater range of consumer's preferences and they also can benefit from economics of scale and scope (Glaeser 2001).

The coagglomeration of CIs can be mainly explained by pull and push factors. In this sense, soft characteristics, localisation and urbanization economies previously explained attract (pull) the creation of creative clusters in city centres. But, at the same time, there are some agglomeration disavantages that expulse (push) the concentration of these activities in the main city (i.e., higher rental prices, teleworking possibilities, etc.). According to Boix et al. (2014), the results of these effects rely on the number of city centres and the intensity of urbanization economies. For the case of Barcelona they find that most clusters are concentrated in city centre around a focal point or a hub.

Among the main reasons explaining this need for coagglomeration of CIs, Scott (2000, pp. 568-569) argues that even the divergent characteristics among each creative and cultural sector, all of them share this symbolic value feature which makes them locate in the same places within the urban system. On the one hand, this coagglomeration behaviour brings them the possibility to benefit from static and dynamic increasing returns effects (i.e., flexible subcontracting opportunities, learning and innovation phenomena, entrepreneurial spinoff possibilities, etc.). And on the other hand, most of the products and services these industries create can be associated to place-specific connotations. In this sense, if the image of this place is positive (negative) it will reinforce the success (failure) of firms operating there. Then, they benefit from being there (Currid and Williams 2009), that is from the reputation of this place that have cumulated through the years (e.g., the *savoir faire* of Paris, the glamour of Hollywood, the design of Milan, etc.). In short, as Currid and Williams (2010) argue in their works, CIs benefit from their colocation for the same reasons as other industries do, but they may require more concentration for their economic and social interaccions (Banks et al. 2000). Furthermore, what makes them unique is their need to locate near gatekeepers, generate geographic branding, and differentiate over other goods (Scott 1996; Power and Scott 2004).

So, it seems to exist a premium for being there. In other words, creative firms willing to benefit from this place image will accept to suffer from those agglomeration diseconomies as those competitive advantages arising from this symbolic image where large enough to compensate them. Therefore, we expect to find different clusters of CIs in the MAB, but they will be mainly in the city centre possibly to benefit from networking among creative disciplines, from soft characteristics, and also from place-specific image which are more present in some neighbourhoods within the urban area.

**3. Data**

The firms in our sample are located in the MAB, one of the largest metropolitan areas of Europe having an important place in the Mediterranean. It is located in Catalonia, an autonomous region in north-eastern Spain. The MAB has an area of 636 km2 and hosts more than 3.2 million people (42% and 7% of Catalan and Spanish population, respectively). It accounts for 51% and 9% of the Catalan and Spanish GDP, respectively. The MAB is composed of 36 municipalities (see Table A (Annex) and Figure 1), of which its capital (Barcelona) accounts for 50% of the population of the whole area.

[INSERT TABLE A HERE]

[INSERT FIGURE 1 HERE]

This study uses micro-geographic data from the SABI database (Bureau van Dijk) for the year 2012. SABI contains comprehensive information on firms in Spain, detailed by firms' geographical information (plain coordinates), employment, and among others characteristics at the 3-digit

NACE level.[5] The SABI database provides information of 620,390 workers and 44,164 firms located in the MAB in 2012.[6]

Regarding the classification of CIs, we follow the proposal of UNCTAD (2010) as it is the broader in terms of industries considered. In addition, this classification is the most widely accepted among researchers (see Boix and Lazzaretti 2012b). UNCTAD's classification includes both manufacturing and service industries. Even so, the relevance of service creative firms is greater than manufacturing ones. We consider both the aggregation of CIs and each industry separately as we aim to examine whether agglomeration patterns of CIs differ from those of non-CIs, and also if these patterns change across specific industries of CIs.

According to this, 4,552 are CIs, which represents a 10 percent of the total activity in the MAB (see NACE-93 industry classification in Table 1).[7] In terms of employment, there are 58,159 creative workers (about the 9% of total employment). Moreover, it is important to say that 49% of the total creative employment of Catalonia is generated in Barcelona (Ajuntament de Barcelona and and IERMB 2013). We want to point out that we only use information about those CIs sectors having 50 firms or over in the sample (97 sectors of the 190), since those sectors comprising less than 50 firms could bring unreliable predictions of agglomeration patterns (Table B (Annex) contains the finally selected CIs).

[INSERT TABLE 1 HERE]

Beyond these data issues, also firm size should be taken into account. It is one of the most important factors explaining location patterns according to Scott (1986; 1988). Whereas smaller firms have a greater need for clustering in order to get access to other services and diminish transaction costs, bigger corporations are less dependent on external services so their need to collocate is minor. Thus, we split both kinds of firms into four categories according to the number of employees: Micro (less than 10 workers), Small (11 – 49 workers), Medium (50 – 249 workers) and Large (more than 250 workers).[8]

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[5] This level of disaggregation is used for convenience, as it makes clearer the interpretation of results and it is the higher level of disaggregation that can be used when working with CIs. However, we should bear in mind that the M-functions are additive in industries, so that the *M* function values in each 3-digit industry are the aggregate of the correspondent 4-digit industries. Even so, we have calculated *M* functions at 4-digit level and results do not vary at all.

[6] We obtained 44,164 firms of a sample of 95,985 firms in the MAB, after excluding data of those firms that do not incorporate their plane coordinates and employment in 2012 and those ones that opened and closed in the same year.

[7] We do not consider Photography and Design Industries (748) as CIs since our level of aggregation involve mostly non-creative activities.

[8] We follow the European Commission's criteria when creating these categories. See https://www.boe.es/buscar/doc.php?id=DOUE-L-2003-80730.

[INSERT TABLE 2 HERE]

The distribution of firms by size can be found in Table 2. The main conclusions that can be drawn are that the distribution of CIs and Non-CIs by size is almost the same and that both kinds of firms operate at a very small scale (roughly 82% of CIs and Non-CIs can be classified as Micro). This fact is in accordance to the aforementioned comments on the relevance of self-employment and freelancers on the CIs' context (Scott 2006).

### 3.1 Preliminary evidence

In this section, we aim to provide an initial intuition about the location patterns for CIs, Non-CIs and subsectors of CIs in the MAB. To do that we use Kernel Density Heatmaps[9], this should give us a first idea about the agglomeration patterns of CIs.

Figure 2 allow us to compare the agglomeration and coagglomeration of CIs to Non-CIs in the MAB in 2012. This figure shows significant overlap between red spots indicating the highest density of firms for both types of firms. However, these maps reveal that Non-CIs are more homogeneously located along the MAB, whereas CIs are mostly agglomerated in the centre of Barcelona which is in accordance to previous findings (Boix et al. 2013b).

[INSERT FIGURE 2 HERE]

As can be seen in Figure 3, these results change with firms' size. The spatial distribution and agglomeration of CIs firms by size shows that firms with less than 10 employees tend to concentrate in a more obvious way. Moreover, Small, Large and Macro CIs clusters overlap also in the centre of the Barcelona, where there is a dense network of cultural infrastructures, consumers and suppliers. Thus, the agglomeration and coagglomeration results seem to be robust to the change in the size for CIs.

[INSERT FIGURE 3 HERE]

Additionally, it is interesting to compare the specific patterns of agglomeration and coagglomeration of selected CIs (Figure 4). Interestingly, there is a clear spatial agglomeration in the sense that some of those CIs locate mainly in the same parts of the city. On the one hand, it should be highlighted that most cultural industries (Arts & Entertainment, Cinema and TV & Radio) are concentrated in the historical districts of the city of Barcelona, which could be related to their

[9] Heatmaps have been computed with QGIS, by implanting a bandwidth of 500 metres.

greater need for proximity to cultural and 'soft' factors. Barcelona centre also shows a great density of Publishing, Architecture and Engineering, Advertising and Software activities. On the other hand, manufacturing CIs such as Clothing, Printing, and Costume Jewellery, are concentrated along other points of the MAB. Surprisingly, some of the most technological and innovative activities (i.e. Software or Natural Science R&D) are mostly located at the centre of Barcelona and not in areas as Sant Cugat or Cerdanyola del Vallès, where the most important University and Technological Campus are located. At this point, it is important to notice that although some high-tech activities have been suburbanised towards the periphery of the MAB, the city centre (Barcelona) still acts as an important magnet.

[INSERT FIGURE 4 HERE]

Having established a high presence of creative employment in the MAB, we now turn to a more formal the analysis of agglomeration patterns using *M* and *m* functions.

**4. Results**

Here we present the results for the spatial indicators of agglomeration and coagglomeration. All the intra and inter-industry *M* and *m* functions are calculated using data for all the 3-digit level sectors including 50 firms or over.

An extended definition *M* and *m* functions can be found in Appendix A. Here we only introduce an intuitive interpretation of it. The *M* and *m* functions are two relative measures that compare the proportion of firms of interest in the neighbourhood of the reference firms to the proportion of neighbours of interest in the whole area. On the one hand, there is significant agglomeration of firms if the proportion of neighbours of interest in the neighbourhood of interest is larger than that of the whole area. On the other hand, there is significant dispersion of firms if the proportion of firms of interest in the neighbourhood of the reference firms is lower than the whole area (See Marcon and Puech 2010 and Lang et al. 2015). The main difference on the interpretation of *M* and *m* is that for the former is defined at distance *r* and not up to it, as it does the latter.

**4.1 Intra-industry concentration**

First of all, we want to compare the degree of agglomeration of CIs to Non-CIs. Figure 5 shows the *M* functions for the aggregate of both kinds of firms. Whereas Non-CIs do not show significant agglomeration, CIs display significant agglomeration at distances between 0 and 16 km. In this case, the *M* functions peak up to 1 km and then show a continuous decay as distance increases. The maximum concentration peak reaches 2.5 which means that the density of employees in CIs in a radius of less than 1 km is 2.5 times greater than what can be observed in all the MAB.

[INSERT FIGURE 5 HERE]

Although the significance of the previous results, we should consider whether these results change when we split the sample of CIs firms by size. Figure 6 shows the *M* functions for CIs by size. Results follow the previous trend, but the degree of concentration varies by size. More specifically, higher levels of concentration of creative workers at very small radius values are shown as the size of firms decreases (e.g. in the case of micro firms (>10 workers) the peak reaches a value of 7.74, whereas for large firms (>250 workers) the peak value is 2.73)). Moreover, results indicate that the radius of significant concentration is even smaller for larger firms. This result is in accordance to Scott (1986; 1988). That is, smaller firms have a greater need for clustering, while larger firms are less dependent on external services so their need to cluster is minor. Although lower number of large firms (68) makes difficult to reach agglomeration levels of micro firms (3,680), we have also found this result on previous heatmaps figures.

[INSERT FIGURE 6 HERE]

Figure 7 displays *M* functions results for all 11 creative sectors considered (those that comprise more than 50 firms).[10] Almost all the 11 CIs considered show significant agglomeration, 9 are significant for a continuous and discontinuous range of distance at least 1 km and they display M-peaks up to the same distance (1 km). However, Software and TV & Radio activities do not show significant agglomeration results. For all the other sectors, the maximum concentration around the MAB appears for Natural Science R&D where the concentration peak reaches 126 at very small radius values. This means, close to Natural Science R&D firms, the density of employees in the same sector is 126 times greater than what can be observed in the MAB. Moreover, for other significantly concentrated sectors, the peak values are comprised between 5.78 (for Architecture and Engineering) to 33.40 (for Cinema).

[INSERT FIGURE 7 HERE]

The intra-industry *m* functions' results for all creative sectors considered are shown in Figure 8. Seven creative sectors show significant agglomeration or dispersion along all the MAB. However, Natural Science R&D, TV & Radio, Clothing and Costume Jewellery activities do not show significant agglomeration or dispersion.[11] For all the other sectors, we find three different patterns

[10] See Table B on the Annex in order to see to which sectors we are referring with this terminology.

[11] The *m* functions are not supposed to confirm the *M* functions, but to give a complementary view on agglomeration. Note that the main difference between the two functions is that *m* uses a kernel to sum the points, so it gives a maximum weight to those located at distance r (and the weight decreases as the points are

of the *m* function. Firstly, there is the case of Software activities which show significant dispersion from 40 km to 70km. Secondly, we find a clear pattern for those activities clearly based on symbolic knowledge. Specifically, those sectors are Architecture and Engineering, Advertising, Cinema, Arts and Entertainment and Publishing. They show significant agglomeration from 0 to 10 km, and they decay until showing significant dispersion from 10 to 70 km, approximately. Finally, we find a different pattern for Printing, which first shows significant dispersion from 0 to 10 km and then it increases showing significant agglomeration from 25 to 60 km, approximately. Among them the maximum concentration around the MAB appears for Printing where the concentration peak reaches 2 at 40 km. This means, close to Printing firms, the proportion of firms in the same sector is 100% at this distance is greater than what can be observed in the whole MAB.

[INSERT FIGURE 8 HERE]

Whereas the *M* function provides the intensity – the cumulative agglomeration (dispersion) of the sector of the whole area – of agglomeration (dispersion) up to a determined distance *r*, the *m* function captures all clusters or agglomeration (dispersion) emerging along all the area and, also it situates them along it.

Let us give a practical example. We compare heatmaps, *M* and *m* results for Publishing and Printing sectors, which have always been highly interconnected in terms of input and output linkages (Boix 2013c). In the first column of Figure A (Annex) we see the concentration of these sectors in certain areas of the MAB. While Publishing is highly concentrated in one cluster, Printing has several focal points of concentration throughout the MAB. Regarding the *M* function, we see that both show a clear significant agglomeration at distances very close to zero, and how this agglomeration rapidly decays indicating that there is a clear clustering of these activities. Lastly, results for *m* show how the agglomeration we found for Publishing is located in one unique point of the entire MAB and once distance increases, these clusters are disappearing until they show dispersion. In contrast, Printing describes the opposite case. Clusters occur once we move through the MAB. In other words, the evidence that heatmaps give us is reflected in *M* and *m* functions, since the first one indicates how intense this agglomeration is and how it decays and, the second one shows how there is a cluster of Publishing at the centre of Barcelona and that is agglomerated at reduced distances, while Printing shows a decentralised agglomeration. This result is clearly linked with decentralisation of mature activities theory (Scott 1988). That is, those mature industries which are not so depending on symbolic knowledge and face-to-face interaction among activities,

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located further from this distance), while the *M* sums all the points found in a certain radius. So we would actually not expect them to behave similarly moves outward from urban centres where they obtain more advantages in costs since their binding have already established. Instead Publishing needs to be at the city centre to take advantage of these aforementioned factors.

[INSERT FIGURE A HERE]

Bearing in mind these results we should clarify that in *M* functions when it appears a significant agglomeration at distances very closed to zero, it does not involve that this agglomeration should be at the central point of the whole area. However, when we compare this result with the heatmap it allows us to say that this agglomeration emerges at the city centre. Indeed, these results are confirmed by *m* functions, since in them we see how this agglomeration becomes into dispersion when we get away from the mean centre.

To sum up, previous findings imply that for CIs, agglomeration is urban rather than metropolitan, whilst for the rest of activities – less dependent on symbolic knowledge and tacit interaction – the role played by peripheral metropolitan areas is stronger. Furthermore, they confirm our expectations about the great need of agglomeration of these industries on those areas they find the key factors enhancing their activity.

**4.2 Inter-industry concentration**

Aggregate results of coagglomeration of CIs and Non-CIs are shown in Figure 9. Concretely, inter-industry *M* results test whether the relative density of employees in one industry located around those of the reference industry is larger or smaller in a radius r (meters) than the observed for the whole area. There is significant coagglomeration, if and when, both symmetric cases exceed the significance bands. Then, the first conclusion we can draw is that CIs and Non-CIs do not colocate in the MAB. Concretely, Non-CIs are repulsed by those of CIs. It appears at zero km, where the *M* function reaches 0.85. Moreover, results for the coagglomeration of CIs around Non-CIs are not significant.

[INSERT FIGURE 9 HERE]

However when we calculate inter-industry *M* functions for CIs by size (in terms of number of workers) we find some interesting facts (see Figure 10). On the one hand, previous results are confirmed by obtaining not significant results for the coagglomeration of CIs and Non-CIs for the cases of small, medium and large subsamples. On the other hand, we do find significant coagglomeration for Micro CIs settled around those in Micro Non-CIs. The peak value is equal to 3.49 up to 1 km. The coagglomeration of Micro Non-CIs located around those of Micro CIs is also important, showing a peak value of 3.29 up to 1 km. This shows that there is a relevant coagglomeration between both activities which would has been neglected if we had not considered size differences. Actually, this result is in accordance to the traditional discourse saying that economic activities are attracted to CIs firms due to their knowledge spillovers in therms of creativity and innovation, and this is more important between smaller firms (Lee et al. 2004 and De Jong et al. 2007).

[INSERT FIGURE 10 HERE]

Despite the forcefulness of previous results, it could be interesting to analyse the coagglomeration patterns of particular CIs' sectors. Figure 11 shows inter-industry significant *M* functions results for selected CIs.[12] Results for significant inter-industry concentration can also be found in Table 3. According to these results, many industries seem to be coagglomerated around other CIs. Among those, the greater significant agglomeration is shown for Cinema, which is attracted by those of Publishing, with a peak value of 6 up to 0 km. The agglomeration of Publishing around those of Cinema is also important: the maximum degree of agglomeration is 5.52 up to 1 km. This shows that there is a clear coagglomeration between these industries. Regarding the remaining industries, the most obviously coagglomerated industries are Publishing and Advertising, Cinema and Arts & Entertainment, Advertising and TV & Radio, Advertising and Cinema. And to a lesser extent we find coagglomeration between Publishing and Software, Publishing and TV & Radio, Publishing and Arts & Entertainment, Software and Architecture & Engineering, Software and Advertising, Software and Cinema, Architecture & Engineering and Advertising, Architecture and Engineering and Cinema, Advertising and Arts & Entertainment, and for Cinema and TV &Radio. These results for colocation uphold previous findings as those of Scott (2000), De Propris et al. (2009a), Currid and Williams (2009; 2010; 2011) and, also for the Barcelona's case they back up Boix et al. (2014)' findings.

[INSERT FIGURE 11 HERE]
[INSERT TABLE 3 HERE]

On the other hand, the greater degree of segregation around the MAB is observed for firms of Printing, which are repulsed by those of the Publishing sector. It appears up to 3 km, where the M reaches 0.55. We also find significant dispersion for the following industries: Software and Printing, Advertising and Printing, Cinema and Printing, TV&Radio and Printing, and for Arts & Entertainment and Printing. Nevertheless, all these results must be read cautiously. We should bear

[12] Figure 11 only shows significant results. Even so, non-significant results are available upon request.

in mind that we cannot strongly consider that there is an obvious dispersion for two industries since, according to this methodology, significant dispersion is only demonstrated for some cases.

To sum up, we have find that there several clusters of CIs in the MAB, that most of them coagglomerate around the most historic and central neighbourhoods of Barcelona and that while input-output linkages certainly explain this high degree of coagglomeration for the most cultural and traditional activities, manufacturing CIs – like Clothing or Printing – are quite dispersed and they have been decentralised because of their minor need of benefiting from this symbolic knowledge, face-to-face interaction and place image (Scott 1988; 2000; 2006).

## 5. Discussion and Conclusions

The main goal of this paper was to provide a deep intra-metropolitan analysis of the intensity and extent of the agglomeration and coagglomeration of creative industries (CIs) within the Metropolitan Area of Barcelona (MAB). Previous studies have provided the basis for the understanding of CIs' clusters. However, most of these studies are limited by the use of aggregated data and area-based measures, comprising a more than possible bias across different geographic scales. Moreover, an important aspect in CIs' theory is his essential need for concentration in space in comparison to non-creative activities, which has not been sufficiently dealt with in empirical works.

Therefore, with this paper we contribute to the literature on CIs clustering by comparing non-CIs to CIs agglomeration patterns and also those of different subgroups of CIs. Indeed, we deal with the aforementioned limitations by introducing for the first time the relative distance-based measures $M$ and $m$ on their analysis. Additionally, we have also analysed the fact that when working with agglomeration of CIs at intra-metropolitan level, the heterogeneous spatial distribution of their essential sources of agglomeration (i.e., amenities, cultural infrastructures, etc.) is favouring the concentration of creative activities within some focal neighbourhoods of the city. Concretely, our preliminary results suggest that *i)* non-CIs and CIs agglomerate in a different way. Whilst non-CIs tend to disperse along all MAB, CIs are more clustered around the centre of Barcelona, that *ii)* each CIs has similar agglomeration behaviour, being that most of them are highly agglomerated at small distances and this agglomeration rapidly decays as distance increases, and that *iii)* CIs coagglomerate in the same areas of the MAB – especially in some central neighbourhoods of Barcelona.

All these results confirm our preliminary expectations and also complement previous works. In this sense, they endorse the theoretical discourse of CIs' greater need for spatial proximity in relation to non-creative activities in order to benefit from symbolic knowledge, networking, face-to-face interaction and also how the CIs trend to coagglomerate remains consistent wherever they locate (Currid and Williams 2010). Moreover they complement Boix et al. 2014's findings, since until now it was the sole study applying a continuous space method to deal with the agglomeration and coagglomeration of CIs. We also find that CIs are highly agglomerated in Barcelona centre around a focal point; but, besides that we are able to say to what extent and intensity they agglomerate and coagglomerate within the city.

At this point, these findings raise some policy implications. Even if most CIs share a common spatial pattern of agglomeration, creative strategies should take into account both sectoral specificities of each creative sector and all these essential elements they share. Because of this evident concentration of creative activities in the city centre, it seems clear that agglomeration advantages largely compensate agglomeration diseconomies of being located on the city centre. Then, it brings out to the debate about the role of public institutions on the development of creative clusters (Musterd and Murie 2010). Since the agglomeration of CIs seems to emerge for its own and it is really explained by a path dependence process, what should it be the actual role of public institutions? Nevertheless, if these clusters emerge in central areas is because there they could find the soft characteristics, connectivity with established producers, intermediaries, markets and consumers. Then, local governments should focus on providing and improving these features in the city. Our results also highlight the great relevance of the Barcelona in terms of agglomeration of CIs. In this sense, the MAB has directed its efforts to move from a manufacturing economy to a more creative and innovative one in order to compete globally. However, evidence found in this article suggests that policy-makers should not apply the same strategies to the whole of the MAB, as seems quite obvious that Barcelona city has a series of features which are clearly magnets for concentration of CIs and which cannot be transferred to other metropolitan municipalities and, consequently, they should complement them rather than compete with them. Therefore, the study of agglomeration patterns of CIs and their determinants can guide the design of appropriate policies to strengthening the city of Barcelona as one of the most representative cultural and creative capitals of Europe.

Fruitful future research will explore how the agglomeration and coagglomeration of each CI varies when we take into account their industrial organisation – in terms of size. Moreover, it would be interesting to expand this analysis in order to identify the reasons why these patterns are observed in the MAB. Finally, as CIs agglomeration is found to be urban rather than metropolitan, we will work on a more detailed scope of the city in order to evaluate how the application of policies favouring the development of CIs may affect the economic and social conditions of involved neighbourhoods.

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## Appendix

This appendix is structured as follows. Appendix A provides details and justification of the methodology employed (*M* and *m* functions). Appendix B and C contain main and additional tables and figures.

### A. Distance-based methods: *M* and *m* functions

Before introducing our methodology, we should justify why we use distance-based methods. Traditional methods to assess spatial concentration of economic activity are cluster-based measures (i.e. the Gini Index, the Herfindhal Index and the Ellison and Glaeser Index). However, these methods evaluate concentration at a given administrative scale (e.g., municipalities, counties, etc.) involving a MAUP.[13] The MAUP leads to empirical results biased across geographical scales (Marcon and Puech 2003; 2010). Moreover, cluster-based methods are not able to properly capture size heterogeneity within industries (Duranton and Overman 2005; 2008). These limitations can be mostly solved by using distance-based methods. Distance-based methods are able to explain spatial structure at different geographic scales simultaneously. They reveal at what distance a significant geographic concentration or dispersion of firms occurs on a territory (Marcon and Puech 2003). The most used distance-based measures are Ripley's K and L functions and Diggle and Chetwynd's D function (Ripley (1976;1977); Besag (1977); Diggle and Chetwynd (1991)). However, these measures do not have some of the fundamental properties that a good concentration measure should respect (Duranton and Overman (2005)): 1) it should be comparable across industries; 2) it should control for the overall agglomeration patterns of industries; 3) it should control for industrial concentration; 4) it should remain unbiased across geographical scales; and 5) it should give the statistical significance of the results.

Therefore, to measure agglomeration and coagglomeration, we use the *M* and the *m* functions, distance-based methods introduced by Marcon and Puech (2003; 2010) and Lang et al. (2015), respectively. Both the *M* and the *m* functions satisfy all aforementioned properties (Duranton and Overman (2005)) and they also control for inhomogeneous space. Indeed, they allow for an easier interpretation of the results.

An alternative distance-based measure that also satisfies these properties is the *Kd*-function used by Duranton and Overman (2005). However, *M*, *m* and *Kd* functions cannot be considered substitutes for each other. While *Kd* and *m* are both probability density functions of point pair distances because they are calculated on the basis of the average number of neighbours at given distance, the *M* function is cumulative, depending on the number of neighbours up to each distance.

[13] See Arbia (2001) for details about how MAUP may bias analyses.

Furthermore, even that the definition of *m* is similar to that of *M* due to they are relative distance-based measures; they differ in that the former is defined at distance *r* and not up to it. Finally, the main difference between *m* and *Kd* is that the former is a relative concentration measure, while the latter is an absolute one.

According to the recommendation given by Marcon and Puech (2010) and by Lang et al. (2015), we calculate the *Kd* functions to give a complete picture of agglomeration for aggregate sectors. Thus, given that the *M and m* functions allow for a straightforward interpretation and comparison of the results, we mainly rely on them for comparing the strength of agglomeration across industries.

***M functions***

We calculate the intra and inter-industry M-functions for every 1000 m between 0 and 20 km at the industry level for Non-CIs and CIs. We use the package *dbmss* for the calculations (Marcon and Puech 2015).We use the plain coordinates (X-Y) for each firm located in the MAB. In the following, we explain a detailed definition of *M* functions of agglomeration and coagglomeration.

*Evaluating agglomeration at intra-industrial level*

The *M* function for intra-industrial spatial agglomeration in a circle of radius *r* for a sector *R* is

$$M = \frac{\sum_{x_i \in R} \frac{\sum_{x_j \neq x_i, x_j \in R} (\left\| x_i - x_j \right\| \leq r) w(x_j)}{\sum_{x_j \neq x_i, x_j \in X} (\left\| x_i - x_j \right\| \leq r) w(x_j)}}{\sum_{x_i \in R} \frac{W_R - w(x_i)}{W - w(x_i)}}$$

where $i = 1,2, \dots, n$ is an index for firm and $w[W]$ denotes [total] employment. The function works as follows. First we identify all firms belonging to sector *R* in the area of study. Here, a *sector* *R* refers to a type of firm (Non-CIs, CIs or subsectors of CIs). For each of these firms, we draw a circle of radius *r* (e.g. 1 km). Within this distance, we count the number of employees belonging to firms in sector $R(w_i)$. We then express the sum of this quantity over $i$ as a proportion of the number of employees belonging to firms in all sectors within the same circle. Next we divide this ratio by sector *R'* employment weight in total employment in the whole area.

The benchmark of the *M* function is one. *M*-values *equal to one* me indicate that whatever the considered radius, there are proportionally as many employees belonging to sector *R* as there are in the global area, or that there is a completely random location of firms in this sector *R*. *M*-values *larger than one* indicate that there are proportionally more employees close to firms in sector *R* in a radius *r* than in the global area, which corresponds to the existence of relative geographic agglomeration of sector R at distance *r*. *M*-values *smaller than one* indicate that there are relatively fewer employees in sector R within a radius *r* than in the global area, or that sector R is relatively dispersed at distance *r*.

We calculate the statistical significance of the *M*-function by constructing confidence intervals for the null hypothesis of independence of firm locations, according to which the firms belonging to sector R locate following the same pattern as the others. We determine these intervals using Monte-Carlo methods in the following way: First, we generate a large number of simulations (100). Next, we choose a confidence level of 5 percent so that the 95 percent confident interval of *M* for each value of *r* is delimited by the outer 5 percent of the randomly generated values. There is significant relative agglomeration (dispersion) in a given sector if the corresponding *M*-values are larger (smaller) than one and are outside the confidence interval bands.

*Evaluating coagglomeration at inter-industrial level*

The inter-industrial version of the *M* function assesses the presence of coagglomeration. This measure has the same properties as the intra-industrial one. *M* functions of coagglomeration for sectors $R_1$ and $R_2$ are defined as:

$$\mathrm{M} = \frac{\sum_{x_i \in R} \frac{\sum_{x_j \neq x_i, x_j \in N} (\|x_i - x_j\| \leq r) w(x_j)}{\sum_{x_j \neq x_i, x_j \in X} (\|x_i - x_j\| \leq r) w(x_j)}}{\sum_{x_i \in R} \frac{W_N - w(x_i)}{W - w(x_i)}}$$

$M_{R_1 R_2}(M_{R_2 R_1})$ depicts the spatial structure of firms belonging to sector $R_2(R_1)$ that are found around sector $R_1(R_2)$. The value shows whether the relative density of firms $R_2(R_1)$ located around those of sector $R_1(R_2)$ is larger or smaller than the observed for the whole area. The statistical significance of the inter-industrial *M* functions is tested using the same methodology of the intra-industry indicator described above, although the construction of the confidence intervals is slightly complicated. Significant values of $M(r, R_1, R_2)$ may be due to interactions between sectors, or to $R_1$ or $R_2$ individual patterns. So, the null hypothesis should control for both $R_1$ and $R_2$ patterns. Thus, the null hypothesis point set for $M_{R_1 R_2}(r)$ is generated by keeping $R_1$ points unchanged and redistributing all other points onto all other locations. We follow the same process for $R_2$. There is significant coagglomeration whenever both values are significantly different from their respective null hypothesis (Marcon and Puech 2003).

***m functions***

We calculate the intra-industry *m* functions for every 1000 m between 0 and 70 km at the industry level for some of CIs sectors.[14] We also use the package *dbmss* for the calculations (Marcon and Puech 2015). We use the plain coordinates (X-Y) for each firm located in the MAB. In the following, we explain a detailed definition of *m* functions of agglomeration.

Following Lang et al. (2015, pp. 3-4), let us consider that our data on firms is defined as points and all these points belong to a point pattern $X$. Two subsets are considered: that of the reference points $R$ (i.e.: the creative sector) and that the neighbouring points of interest $N$ – in our case belonging to the same creative sector as our goal here is only to measure intra-agglomeration. In this case, $R$ is equal to $N$. Then, the *m* function definition is as follows:

$$\widehat{m} = \frac{\sum_{x_i \in R} \frac{\sum_{x_j \neq x_i, x_j \in N} k(\|x_i - x_j\|, r) w(x_j)}{\sum_{x_j \neq x_i, x_j \in X} k(\|x_i - x_j\|, r) w(x_j)}}{\sum_{x_i \in R} \frac{W_N - w(x_i)}{W - w(x_i)}}$$

, where $x_i$ denotes the reference points (firms of the creative sector), and $x_j$ their neighbours (firms on the same sector). $w(x_i)$ is the weight of point $x_i$. $W_N$ is the total weight of the neighbouring points of interest and $W$ is the total weight of all points. In our case, the weights are the number of employees working in those sectors. $k(\cdot)$ is a kernel estimator whose sum can be used to estimate the number of neighbours of point $x_i$ at distance $r$. The authors of the function followed Duranton and Overman (2005) to use a Gaussian kernel of optimal bandwidth as described by Silverman (1986).

The interpretation of the *m* function is quite similar to the *M*'s ones. Then their reference value is one for any distance $r$. *m* values *greater than one* indicate the spatial concentration of points while *m* values *lower than one* express dispersion. Even that, *m* function differs from *M* function by the fact that the former should be read as the relative agglomeration (dispersion) of a specific activity at distance $r$ (as a relative density function measure). Conversely, the later (*M*) should be read it as the relative agglomeration (dispersion) of a specific activity up to distance $r$ (as a cumulative distance-based function).

Like *M* functions, the significance of *m* is given by the confidence interval of the null hypothesis by using Monte-Carlo simulations. Particularly, we generate 100 simulations.

[14] In contrast to what happens with *M* function, here we extend our geographical distance from 20 to 70 km in order to capture all possible clusters of CIs coming up along all the MAB. Moreover, we clarify that results for *M* using the same geographic scale do not vary at all.

## B. Tables

**Table 1. Firm's distribution by Creative Industries' Classification**

| Code | CIs by NACE-93.1 Classification | N. of Firms | N. of workers |
|---|---|---|---|
| 177 | Manufacture of knitted and crocheted apparel | 13 | 546 |
| 181 | Manufacture of leather clothes | 6 | 40 |
| **182** | **Manufacture of other wearing apparel and accessories**[a] | **208** | **2,335** |
| 183 | Dressing and dyeing of fur; manufacture of articles of fur | 8 | 44 |
| 191 | Tanning and dressing of leather | 3 | 23 |
| 192 | Manufacture of luggage handbags and the like saddlery and harness | 13 | 1,249 |
| 193 | Manufacture of footwear | 6 | 41 |
| **221** | **Publishing** | **420** | **5,576** |
| **222** | **Printing and service activities related to printing** | **632** | **6,655** |
| 223 | Reproduction of recorded media | 14 | 51 |
| 362 | Manufacture of jewellery and related articles | 46 | 375 |
| 363 | Manufacture of music instruments | 3 | 31 |
| 365 | Manufacture of games and toys | 15 | 153 |
| **366** | **Other manufacturing activities (as costume jewellery)** | **102** | **1,099** |
| **721** | **Hardware consultancy** | **289** | **7,215** |
| 722 | Software consultancy and supply | 25 | 155 |
| **731** | **Research and experimental development on natural sciences and engineering** | **83** | **1,210** |
| 732 | Research and experimental development on social sciences and humanities | 44 | 355 |
| **742** | **Architectural and engineering activities and related technical consultancy** | **1,085** | **13,292** |
| **744** | **Advertising** | **755** | **6,942** |
| **921** | **Motion picture and video activities** | **263** | **3,333** |
| **922** | **Radio and television activities** | **55** | **2,688** |
| **923** | **Other artistic and entertainment activities** | **446** | **3,633** |
| 923 | Library archives, museums and other cultural activities | 18 | 1,118 |
| | **Total** | **4,552** | **58,159** |

[a]Sectors in bold are those which finally have been selected due to they have more than 50 firms.

*Source: Authors' Calculations with SABI's database*

**Table 2. Firm's size distribution (2012)**

| Size | Non-CIs | CIs | Total |
|---|---|---|---|
| Micro (1 – 10 workers) | 31,574 | 3,680 | 35,254 |
| | 79.71% | 80.84% | 79.83% |
| Small (11 – 49 workers) | 6,462 | 700 | 7,162 |
| | 16.31% | 15.38% | 16.22% |
| Medium (50 – 249 workers) | 697 | 66 | 763 |
| | 3.42% | 3.19% | 3.40% |
| Large (>250 workers) | 592 | 68 | 660 |
| | 0.56% | 0.59% | 0.56% |
| Total | 39,612 | 4,552 | 44,164 |
| | 100% | 100% | 100% |

*Source: Authors' Calculations with SABI's database*

**Table 3. Firm's distribution by area (2012)**

| Size | Non-CIs | CIs | Total |
|---|---|---|---|
| MAB | 14,475 | 1,285 | 15,760 |
| | 37% | 28% | 36% |
| BCN | 25,137 | 3,267 | 28,404 |
| | 63% | 72% | 64% |
| ALL MAB | 39,612 | 4,552 | 44,164 |
| | 100% | 100% | 100% |

*Source: Authors' Calculations with SABI's database*

**Table 4. Inter-industry concentration by enterprise type, selected industries (all distances)[15]**

| Central industry | Around industry | M-peak | Distance at which M-peak appears (Km) |
|---|---|---|---|
| Publishing | Software | 1.36 | 2 |
| Software | Publishing | 1.48 | 2 |
| Publishing | Advertising | 4.60 | 0 |
| Advertising | Publishing | 3.14 | 0 |
| Publishing | Cinema | 6.03 | 0 |
| Cinema | Publishing | 5.52 | 0 |
| Publishing | TV & Radio | 2.02 | 2 |
| TV & Radio | Publishing | 10.47 | 0 |
| Publishing | Arts & Entertainment | 1.32 | 4 |
| Arts & Entertainment | Publishing | 1.33 | 2 |
| Printing | Costume Jewellery | 5.02 | 0 |
| Costume Jewellery | Printing | 4.92 | 0 |
| Software | Architecture & Engineering | 1.45 | 0 |
| Architecture & Engineering | Software | 1.36 | 2 |
| Software | Advertising | 1.39 | 0 |
| Advertising | Software | 1.35 | 2 |
| Software | Cinema | 1.35 | 4 |
| Cinema | Software | 1.21 | 5 |
| Architecture & Engineering | Advertising | 2.43 | 0 |
| Advertising | Architecture & Engineering | 1.23 | 1 |
| Architecture & Engineering | Cinema | 1.26 | 6 |
| Cinema | Architecture & Engineering | 1.58 | 2 |
| Advertising | Cinema | 1.40 | 1 |
| Cinema | Advertising | 1.54 | 1 |
| Advertising | TV & Radio | 1.86 | 2 |
| TV & Radio | Advertising | 4.97 | 0 |
| Advertising | Arts & Entertainment | 1.25 | 2 |
| Arts & Entertainment | Advertising | 1.23 | 3 |
| Cinema | TV & Radio | 1.89 | 2 |
| TV & Radio | Cinema | 34.05 | 0 |
| Cinema | Arts & Entertainment | 4.16 | 0 |
| Arts & Entertainment | Cinema | 6.50 | 0 |

*Source: Authors' Calculations with SABI's database*

[15] These M-functions results have been calculated in a distance range of 20 km.

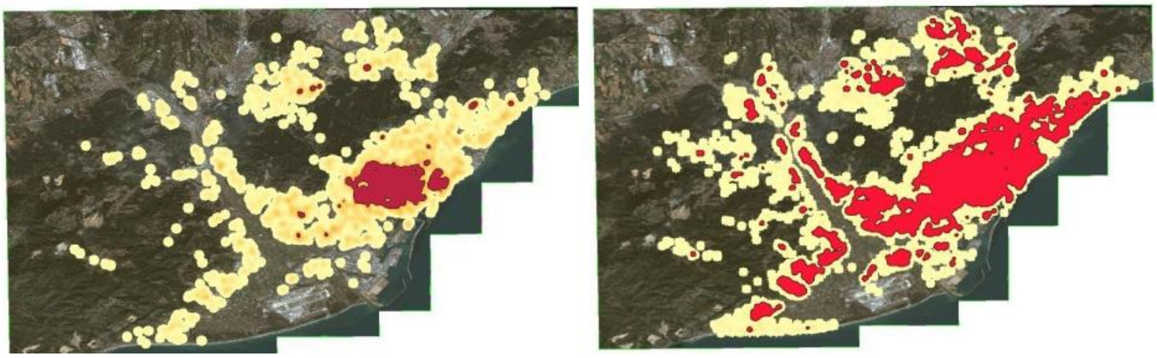
## C. Figures

**Figure 1. Study Area A: The Metropolitan Area of Barcelona**


*Source: www.geoportalcartografia.amb.cat*

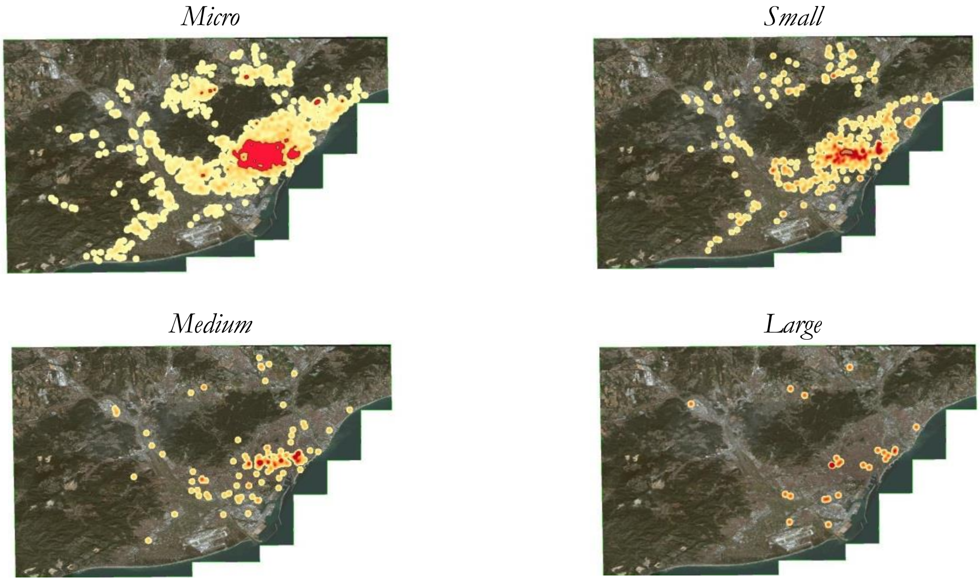
**Figure 2. Heatmaps for CIs and Non-CIs in the MAB**

*CIs* *Non-CIs*



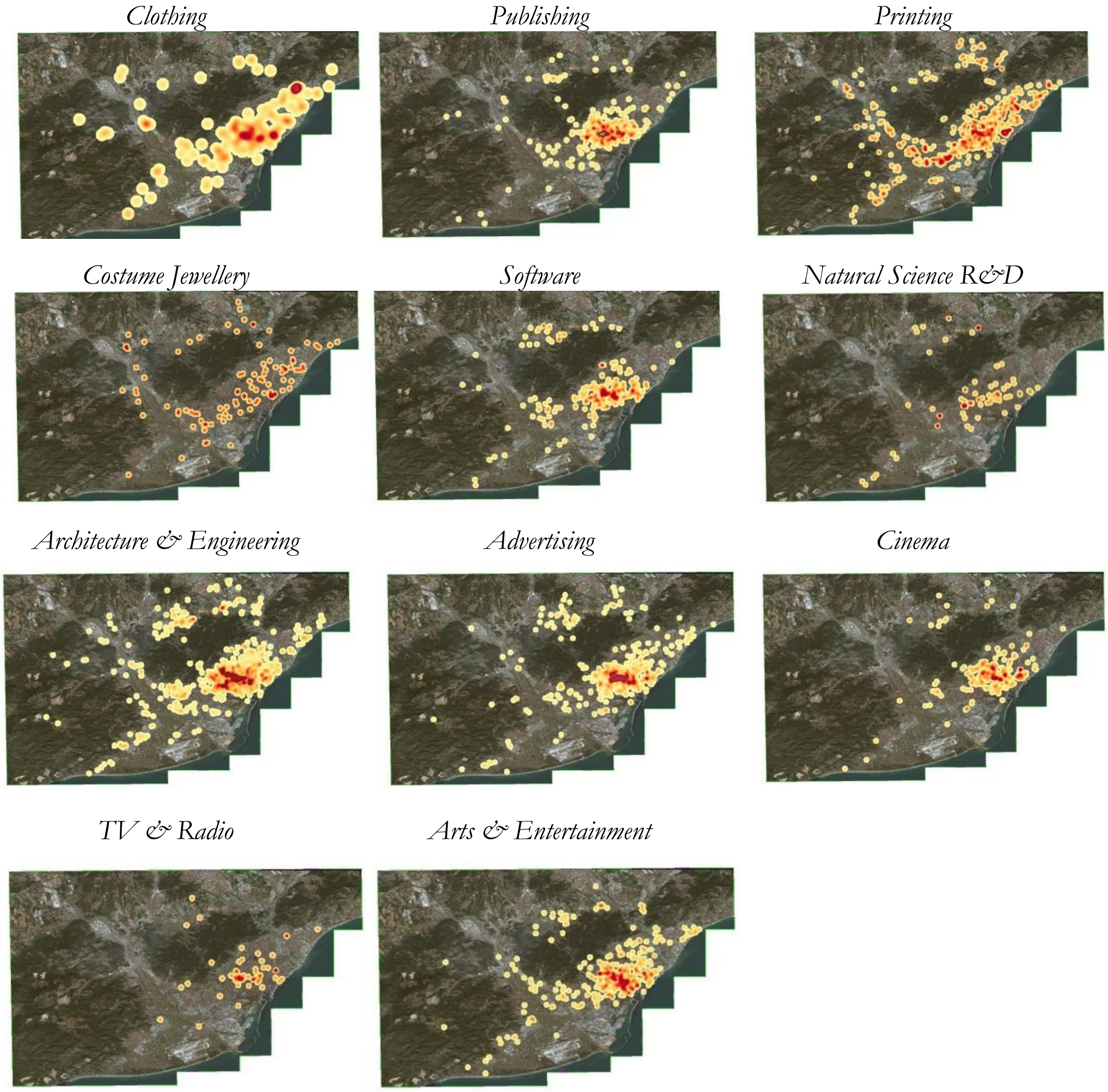
*Source: Authors with data from SABI's database*

**Figure 3. Heatmaps for CIs by Size in the MAB**




*Source: Authors with data from SABI's database*

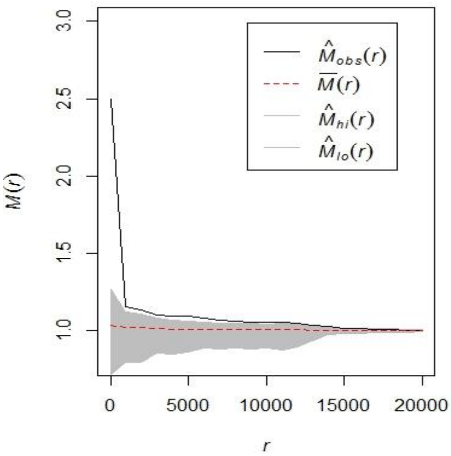
**Figure 4. Heatmaps for CIs in the MAB: selected industries**



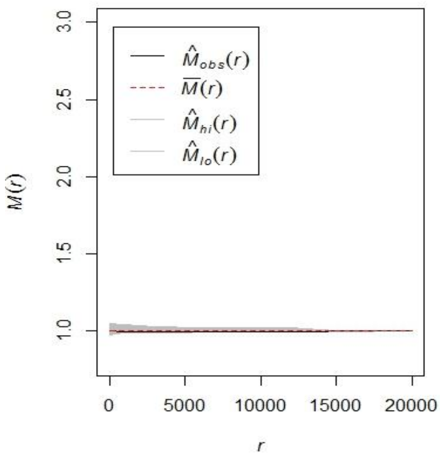

*Source: Authors with data from SABI's database*

**Figure 5. Intra-Industry M-functions by type of firm**

*Creative Industries*



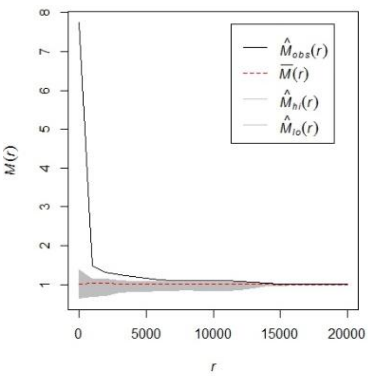

*Non-Creative Industries*



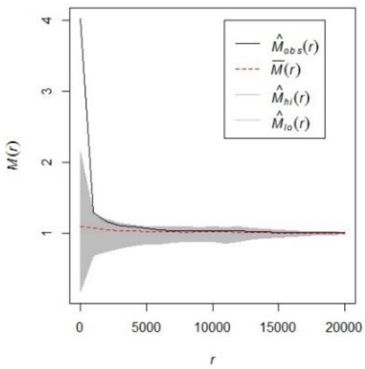

*Source: Authors' Calculations with SABI's database*

**Figure 6. Intra-Industry M-Functions for CIs by size**

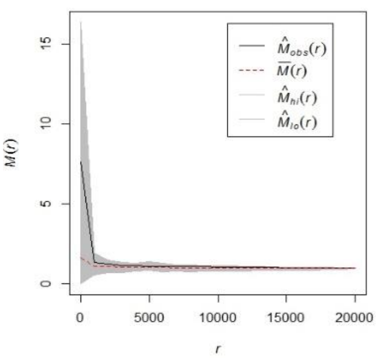
*Micro Creative Industries*



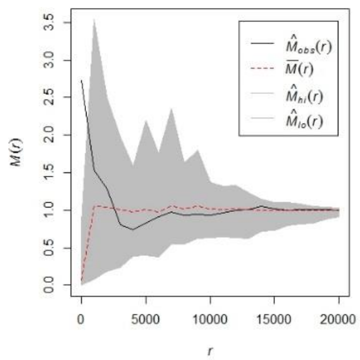

*Small Creative Industries*




*Medium Creative Industries*



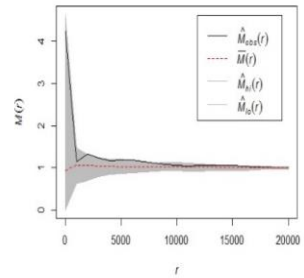

*Large Creative Industries*



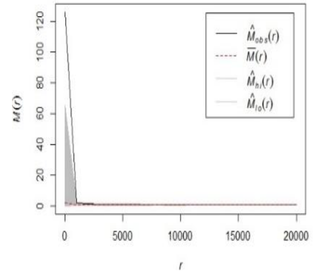

*Source: Authors' Calculations with SABI's database*

**Figure 7. Intra-Industry M-Functions by CIs**

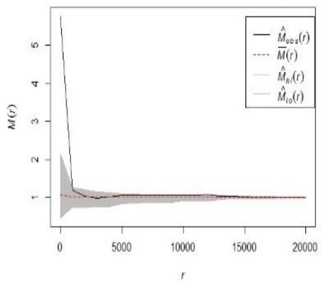
*Software*



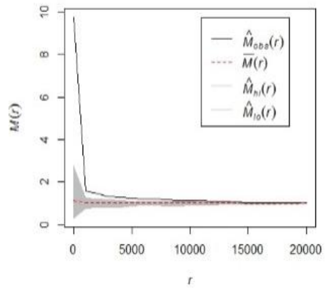

*Natural Science R&D*



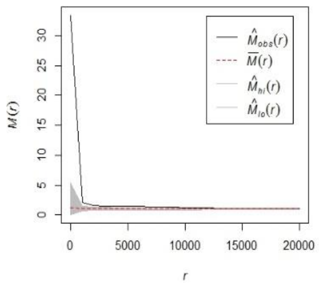

*Architecture & Engineering*



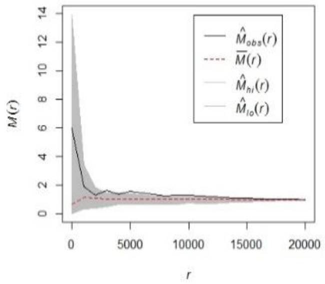

*Advertising*



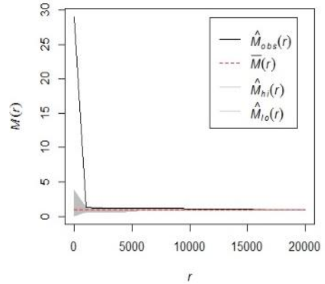

*Cinema*



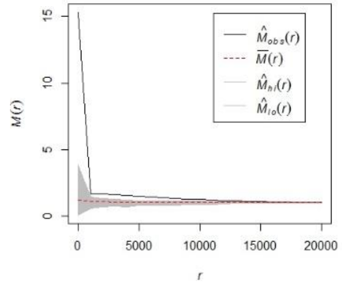

*TV & Radio*




*Arts & Entertainment*



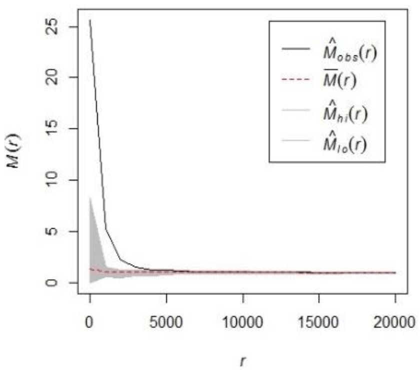

*Publishing*



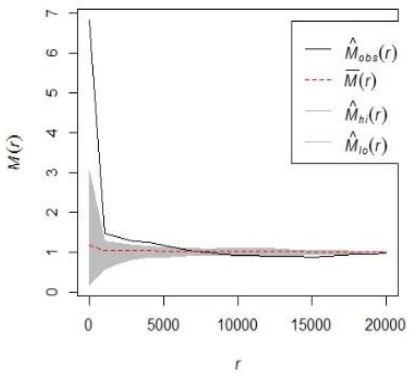

*Source: Authors' Calculations with SABI's database*

**Figure 7. Intra-Industry M-Functions by CIs (cont.)**

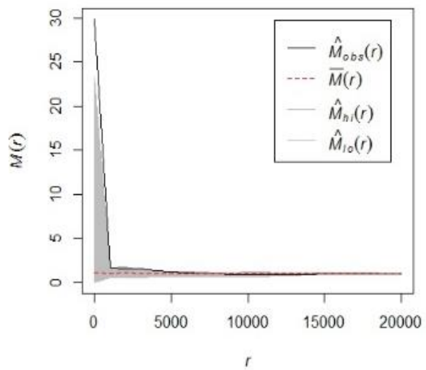
*Clothing*




*Printing*

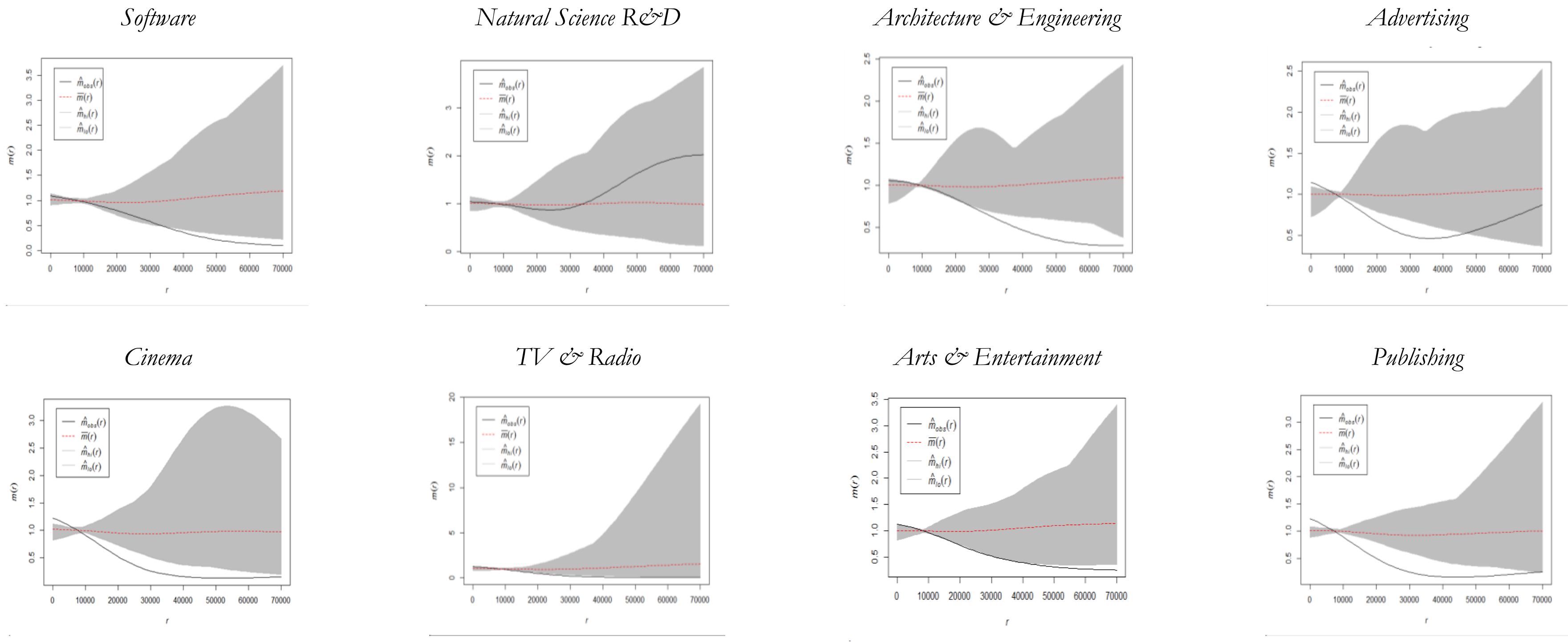



*Costume Jewellery*




*Source: Authors' Calculations with SABI's database*

**Figure 8. Intra-Industry m-Functions by CIs[16]**

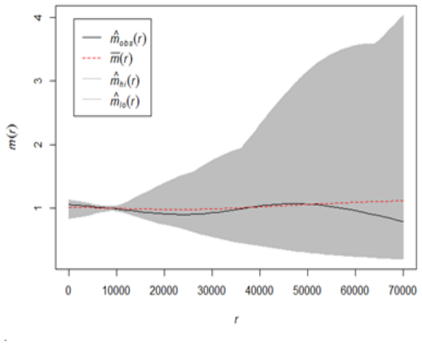



*Source: Authors' Calculations with SABI's database*

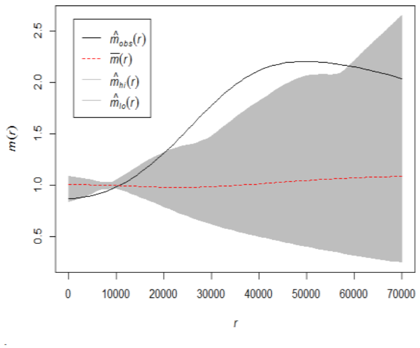
[16] These figures should be read as follows: In the case of Publishing for instance, the proportion of firms of the same sector at 1 km is 20% higher than in the whole area. While at 20 km this proportion is 50% lower than in the whole area. The *m* function is significant as long as the function is outside the grey bands.

**Figure 8. Intra-Industry m-Functions by CIs (cont.)**

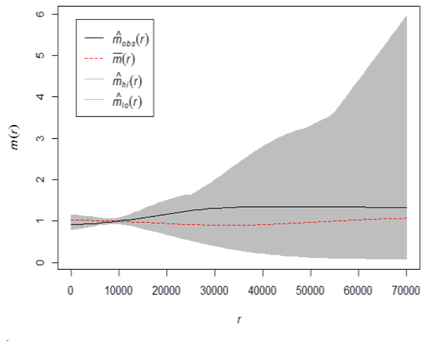
*Clothing*




*Printing*



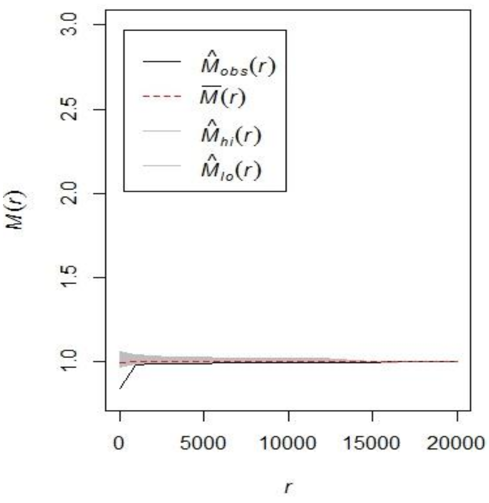

*Costume Jewellery*



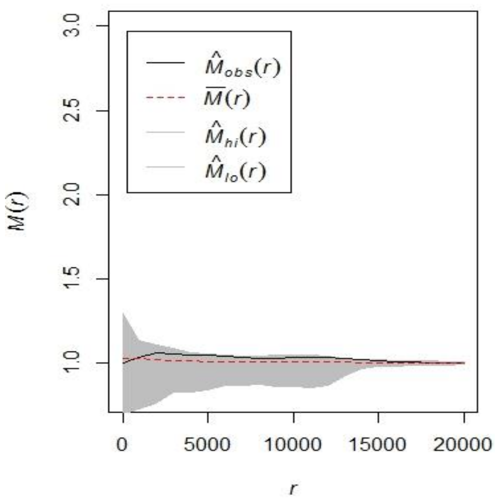

*Source: Authors' Calculations with SABI's database*

**Figure 9. Inter-Industry M-Functions by type of firm**[17]

*a. CIs vs. Non-CIs*




*b. Non-CIs vs. CIs*

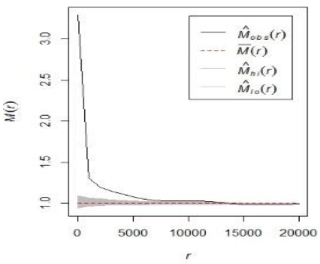



*Source: Authors' Calculations with SABI's database*

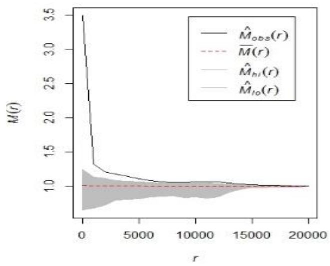
[17] These figures should be read as following: Figure *a* shows whether the relative density of employees in Non-CIs located around those of CIs is larger or smaller in a radius r (meters) than the observed for the whole area. And Figure *b* shows whether the relative density of employees in CIs located around those of Non-CIs is larger or smaller in a radius r (meters) than the observed for the whole area.

**Figure 10. Inter-Industry M-Functions by size.**

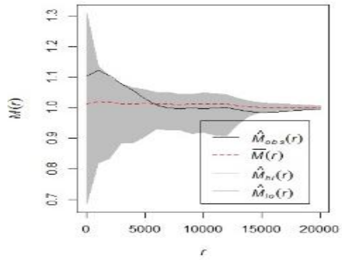
*(Micro) CIs vs. Non-CIs*



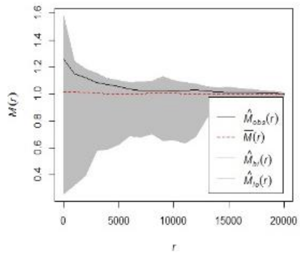
*(Micro) Non-CIs vs. CIs*



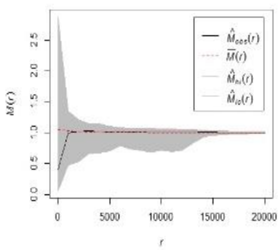
*(Small) CIs vs. Non-CIs*



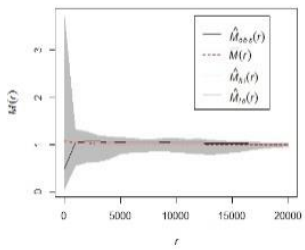
*(Small) Non-CIs vs. CIs*



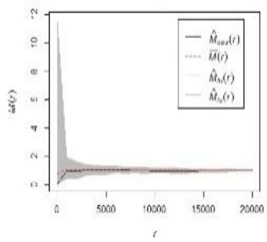
*(Medium) CIs vs. Non-CIs*



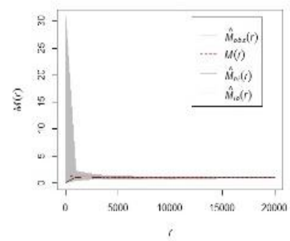
*(Medium) Non-CIs vs. CIs*



*(Large) CIs vs. Non-CIs*

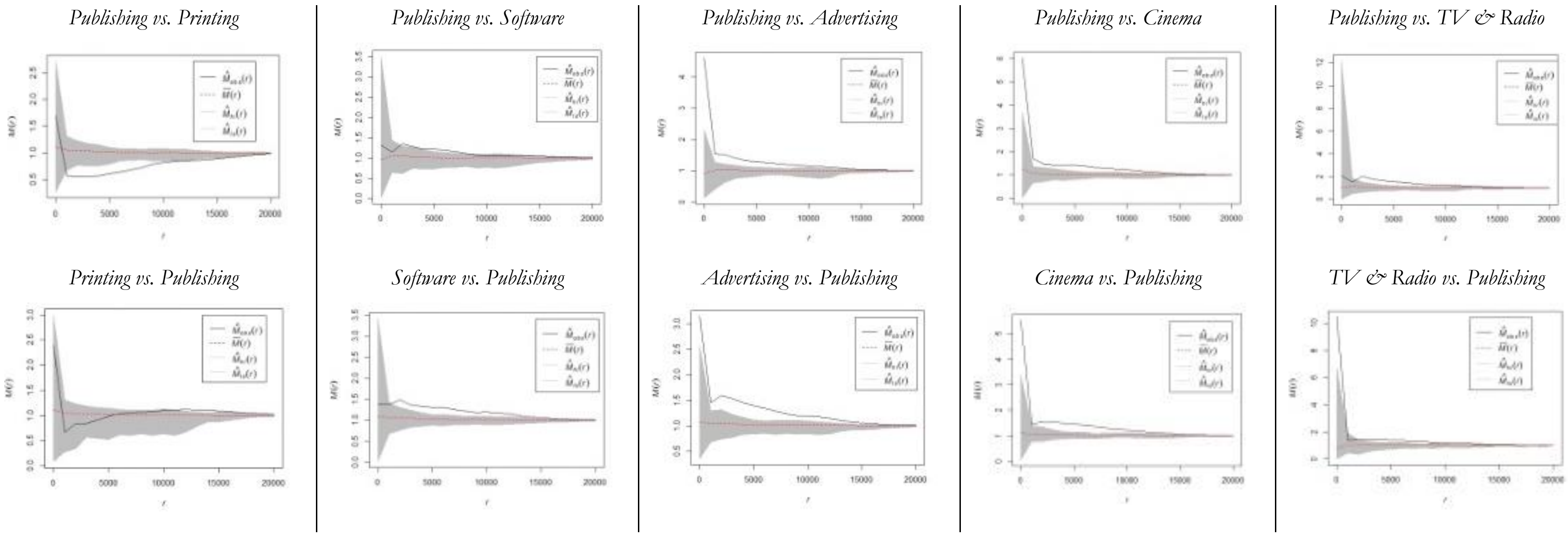


*(Large) Non-CIs vs. CIs*



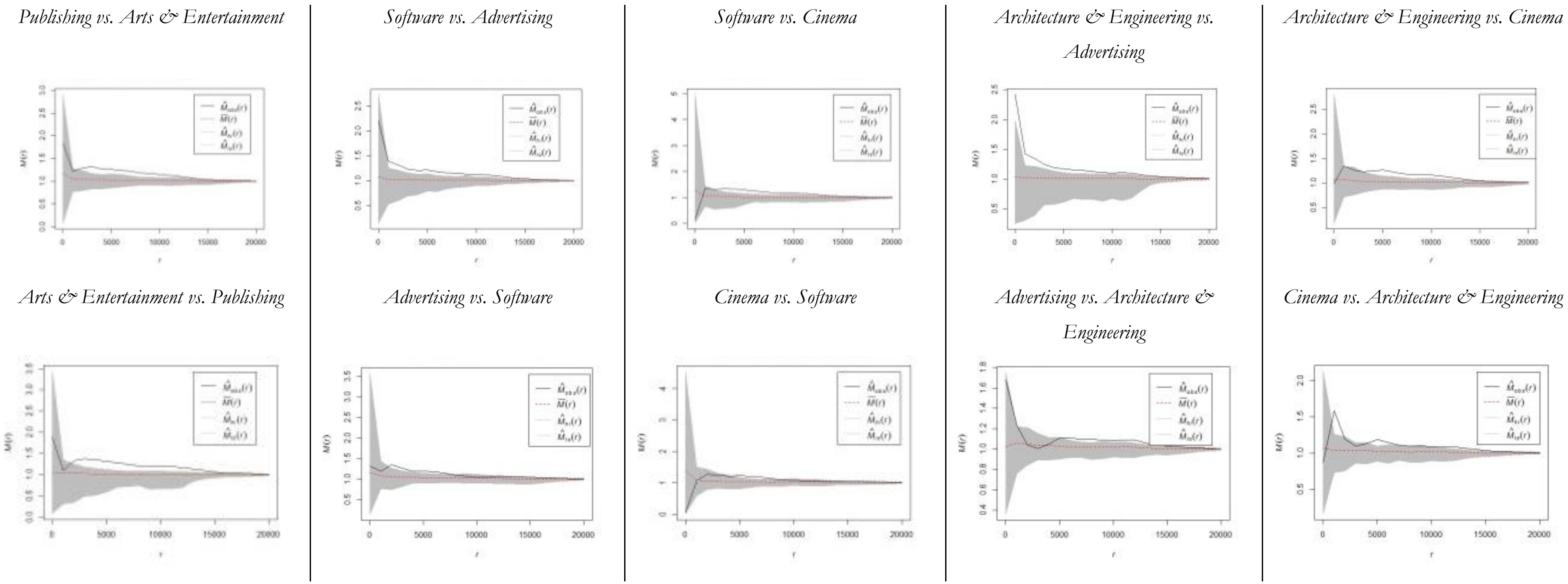
*Source: Authors' Calculations with SABI's database*

**Figure 11. Inter-Industry M-Function by CIs subgroups**



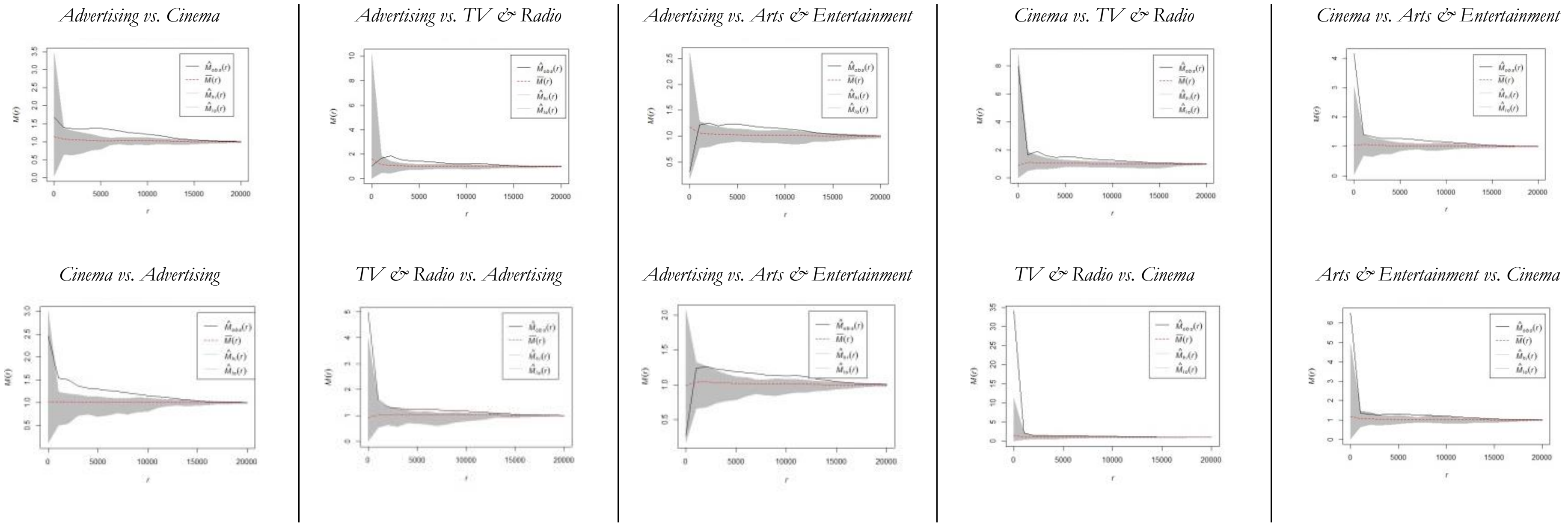

*Source: Authors' Calculations with SABI's database*

**Figure 11. Inter-Industry M-Function by CIs subgroups (cont.)**




*Source: Authors' Calculations with SABI's database*

**Figure 11. Inter-Industry M-Function by CIs subgroups (cont.)**




*Source: Authors' Calculations with SABI's database*

## Annex

**Table A. Population by MAB's municipalities**

| | Municipality | Population | % Population |
|---|---|---|---|
| 1 | Barcelona | 1,620,943 | 50.04% |
| 2 | Hospitalet de Llobregat, l' | 257,057 | 7.94% |
| 3 | Badalona | 220,977 | 6.82% |
| 4 | Santa Coloma de Gramenet | 120,593 | 3.72% |
| 5 | Cornellà de Llobregat | 87,458 | 2.70% |
| 6 | Sant Cugat del Vallès | 84,946 | 2.62% |
| 7 | Sant Boi de Llobregat | 83,070 | 2.56% |
| 8 | Viladecans | 65,188 | 2.01% |
| 9 | Prat de Llobregat, el | 63,162 | 1.95% |
| 10 | Castelldefels | 62,989 | 1.94% |
| 11 | Cerdanyola del Vallès | 57,892 | 1.79% |
| 12 | Esplugues de Llobregat | 46,726 | 1.44% |
| 13 | Gavà | 46,488 | 1.44% |
| 14 | Sant Feliu de Llobregat | 43,671 | 1.35% |
| 15 | Ripollet | 37,422 | 1.16% |
| 16 | Montcada i Reixac | 34,689 | 1.07% |
| 17 | Sant Adrià de Besòs | 34,482 | 1.06% |
| 18 | Sant Joan Despí | 32,792 | 1.01% |
| 19 | Barberà del Vallès | 32,436 | 1.00% |
| 20 | Sant Vicenç dels Horts | 28,084 | 0.87% |
| 21 | Sant Andreu de la Barca | 27,306 | 0.84% |
| 22 | Molins de Rei | 24,805 | 0.77% |
| 23 | Sant Just Desvern | 15,874 | 0.49% |
| 24 | Corbera de Llobregat | 14,231 | 0.44% |
| 25 | Badia del Vallès | 13,563 | 0.42% |
| 26 | Castellbisbal | 12,407 | 0.38% |
| 27 | Pallejà | 11,255 | 0.35% |
| 28 | Montgat | 10,859 | 0.34% |
| 29 | Cervelló | 8,660 | 0.27% |
| 30 | Tiana | 8,151 | 0.25% |
| 31 | Santa Coloma de Cervelló | 7,964 | 0.25% |
| 32 | Begues | 6,520 | 0.20% |
| 33 | Torrelles de Llobregat | 5,740 | 0.18% |
| 34 | Papiol, el | 4,014 | 0.12% |
| 35 | Sant Climent de Llobregat | 3,900 | 0.12% |
| 36 | Palma de Cervelló, la | 3,023 | 0.09% |
| | MAB | 3,239,337 | 100.00% |

*Source: www.amb.cat*

**Table B. Codification of CIs selected sectors**

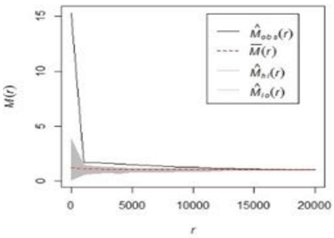
| Code | CIs by NACE-93.1 Classification | Our terminology |
|---|---|---|
| 182 | Manufacture of other wearing apparel and accessories[a] | Clothing |
| 221 | Publishing | Publishing |
| 222 | Printing and service activities related to printing | Printing |
| 366 | Other manufacturing activities (as costume jewellery) | Costume Jewellery |
| 721 | Hardware consultancy | Software |
| 731 | Research and experimental development on natural sciences and engineering | Natural Science R&D |
| 742 | Architectural and engineering activities and related technical consultancy | Architecture & Engineering |
| 744 | Advertising | Advertising |
| 921 | Motion picture and video activities | Cinema |
| 922 | Radio and television activities | Radio & TV |
| 923 | Other artistic and entertainment activities | Arts & Entertainment |

*Source: Authors*

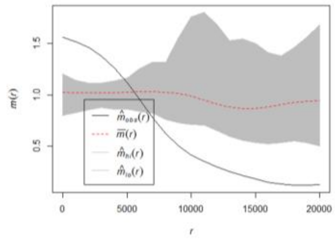
**Figure A. Comparison of concentration measures for Publishing and Printing sectors**

*Heatmap for Publishing*

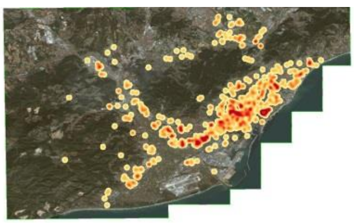
*M function for Publishing*



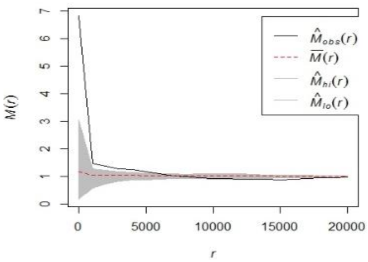

*m function for Publishing*



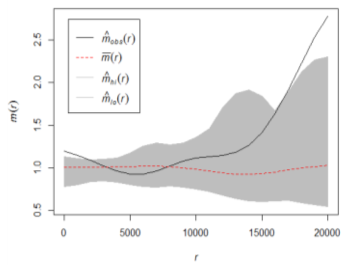

*Heatmap for Printing*



*M function for Printing*




*m function for Printing*




*Source: Authors*