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Hernán Enríquez
Juan Tomás Sayago

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Content

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Hernán Enríquez*
Juan Tomás Sayago**

Abstract

The purpose of this paper is to test the spatial patterns in small and medium size manufacturing firms (11 to 50 employees for small size firms and 51 to 200 for medium size firms) in Bogotá, Colombia, from 2006 to 2008. For this, the Ripley's K(r) function distance based method is used in order to measure the firms´ spatial concentration, using level of employment and firm size as identification variables, for a sample of four ISIC digits industries located inside the urban perimeter.

In this case, the K(r) function allows the reader to establish clustering agglomeration tendencies in each industry and additionally evaluate if dynamic spatial concentration, dispersion, or randomness between firms thru time exists. Evaluating location by firm size would indicate us trends of employment and predominant industry activity in the city, and its relation with other urban features.

Keywords: agglomeration; spatial distribution of firms; Ripley's K function; clusters.

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1 Introduction

The interest of measuring the agglomeration of firms across the city has risen in the academic work. Thru time, several ways to find the evidence of concentration of production have been proposed for specific areas. These measures can be divided into two groups, when the difference is whether or not including a geographic factor.

This paper emphasizes the use of methods that used explicitly the geographic factor, especially those that have been built in a distant way for points of interest on a map. The method used here is the non parametric Ripley's K-function, which estimated tendencies for the most important industrial activities located in Bogotá, chosen by the major number of firms and workers in the city's industry. A special reference is made for small and medium size firms because of the number of this kind of firms and the current legislation about the location of large size firms inside the urban perimeter.

The estimation results show that the majority of these industrial sectors are agglomerated in different areas of the city, viewed by location, distance, and influence area. For some sectors, the evidence shows new concentration areas that create new dynamics for each specific sector in the city.

The paper is ordered in five sections. This introduction is the first of them. The second section depicts the most important concepts about economic sources of agglomeration. The third section shows measures used for estimating firms concentration using the geographic factor, including the Ripley's K function. The fourth section shows the principal results of K function estimates for four digit industrial sectors located in Bogotá. The fifth section concludes.

2 Theoretical background

Since [Marshall, 1890] the discussion on urban agglomeration economies has been classified by labor market interactions, linkages between suppliers, and knowledge spillovers. Duranton and Puga (2004) consider the agglomeration that facilitates the matching between firms and inputs, in which inputs are defined as workers, inputs, and ideas, instead of factors driving agglomeration they model the mechanisms behind the agglomeration. Basically sharing, matching, and learning are the mechanisms considered by the authors.

The sharing mechanism considers four different approaches to generate increasing returns:

- Indivisible factors or facilities, gains from variety, gains from individual specialization, and risk shared [Duranton and Puga, 2004].
- The large fixed cost associated with a facility. To enjoy the good, the cities are viewed as spatial clubs organized to share a common public good or facility. This indivisibility motivates urban increasing returns by directly assuming increasing returns. The large indivisibilities in the provision of public goods are one motivation for this. The most common modeling approach is factory-towns because it considers the whole city labor market devoted to the production of the same good.
- The gains from variety come from differentiated intermediate inputs produced by a monopolistically competitive industry. The increasing returns are due to input sharing. Then resulting equilibriums consider a trade-off between aggregate increasing returns and congestion costs as considered by Henderson (1974).
- The sharing gains from individual specialization follows Adam Smith pin factory hypothesis that there are productivity gains from an increase in specialization when workers spend more time on each task [Smith, 1776]. Three main reasons for this are provided by Smith: first performing the same task improves their dexterity, not having to switch saves time, and greater division of labor fosters labor saving innovations as this was the first tip of learning by doing for economic growth. The sharing risk is caused by labor pooling, based on the idea of "a localized industry gains a great advantage from the fact that it offers a constant skill market".

Another source of agglomeration externalities comes from matching, through different channels: quality of matching, chances of matching, and the mitigation of hold-up problems in matching. The agglomeration increases the quality of the match, as the number of agents to match improves the quality of the match, increases the probability of successful matching, facilitates the process of negotiations, and reduces the costs associated with matching.

The matching effect mitigates hold-up problems. The bilateral relationships between buyers and suppliers or between employers and employees are often full of hold-up problems that remain in the root of contractual incompleteness and specific investments.

The learning activities are a very important activity in terms of the resources devoted to it and in terms of its contributions to economic development [Duranton and Puga, 2004]. [Jovanovic, 1997] states that learning is not a solitary activity taking place in a void. Instead, it involves interactions with others. Cities promote learning by putting together a large number of people.

Marshal emphasized how cities benefit from the diffusion of innovations and ideas; [Marshall, 1890], and Jacobs have stressed how the environment offered by cities improves the prospects for generating new ideas [Jacobs, 1969]. Duranton and Puga classified the learning mechanisms into those dealing with knowledge generation, diffusion, and accumulation [Duranton and Puga, 2004].

The issue regarding knowledge generation in cities is the role played by diversified urban environments that foster search and experimentation. As Jacobs stressed, diversified cities exist because each firm finds it in its best interest to locate in a diversified city while searching for its ideal process [Jacobs, 1969]. But according to Duranton and Puga [Duranton and Puga, 2001] this stage is temporary while a firm is searching for its ideal production process, when it will not benefit from being on a diverse environment.

The diffusion of knowledge can be taken as the transmission of skills and ideas, and the diffusion of information and knowledge. The proximity to individuals with greater skills or knowledge promotes the acquisition of skills and the exchange and diffusion of knowledge. Otherwise the information passed by in social places, the propagation of rumors in cities, and word of mouth learning in neighborhoods. Another channel of information diffusion is the existence of the endogenous central business district that allows the flow of information between firms.

Endogenous growth models account knowledge accumulation built in thru the production of different goods and accumulation of factors [Romer, 1986]. The externalities and spillovers from accumulated factors produce increasing returns to scale. These externalities are included as innovations in the production process and this process of self repeating innovations is the basis for the increasing returns to scale.

3 Methodological background

Measuring the agglomeration through space has become an important aspect for determining the effects of interaction of concentrated firms in specific locations. However, the former measures of these phenomena did not allow authors to explicitly include the proximity of firms in space[1].

This review will focus on two important methods applied to measure agglomeration: the Ellison-Glaeser Index and the K function. These approaches serve to define the concentration of firms through areas in space and distance between points.

3.1 The Ellison-Glaeser index

The agglomeration index proposed by Ellison and Glaeser began a new tradition in measuring this kind of producer's behavior on space. The difference between this index and the conventional ones made for concentration is the inclusion of a geographic factor in the proper measure.

The Glaeser index is computed using an index of geographical concentration as in the equation 1, where the area of analysis is divided into M subareas and S_{mi} is the share of employment of firm i into the area m. x_m is another measure of the subarea size such as the share of population and total employment [Ellison et al., 2007].

$$1)\qquad G_i = \sum_{m=1}^{M} (S_{mi} - x_m)^2$$

Because of the difficulties in comparison across the industry or country data, the geographical index is adjusted, generating the Ellison and Glaeser index:

$$2)\qquad \gamma_i = \frac{\dfrac{G_i}{1 - \sum m x_m^2} - H_i}{1 - H_i}$$

1 Most used measures of agglomeration are related to those of economic activity concentration and rely on the Hirschman and Hirschman Herfindal index.

Where H_i is the plant level Herfindahl index of industry i [Ellison et al., 2007]:

3) $$H_i = \sum_{k=1}^{N} z_{ki}^2$$

This measure indexes the k plants in industry i using the plant share of employment in total employment in the industry.

3.2 The K-function

Instead of using Index based on areas as Ellison and Glaeser, we study another way to measure how firms agglomerate in space based on distance between pairs of firms that is now in use by many research projects. The Ripley's K-function is one of the measures classified in this field.

This method uses non parametric statistical procedures to calculate densities of firms in a continuous space and to control for the unit scale problem[2]. The basis for calculating the Ripley's K function is a continuous map of points relating firms of a specific industry.

The basic computation of K function uses the Euclidean distance between each pair of firms for estimating the density of these firms through the distance on map. Formally, following Duranton and Overman, for n establishments and their distances $dij–i = j$ and i, j =1, 2,...,n, the K-function is denoted as [Duranton and Overman, 2005]:

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

Where d is any arbitrary point, h is a bandwidth, and f is a kernel function.

For the purpose of this paper, the basic K function has been modified, allowing then the control for firm size through level of employment [Duranton and Overman, 2005]:

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

Where $e(i)$ measures the number of workers of firm i.

2 This feature allows the reader to compare results across different geographical scales.

The hypothesis to be proved here is related to the randomness of localization among the firms in the same industry. If the hypothesis is rejected, there will be some evidence of patterns of localization (agglomeration) within a specific industrial sector. This could be seen in the semi Gaussian shape of the empiric K-function estimated for firms that belong to the same industry sector and are also classified by size.

The main advantage of using this method is the capacity to detect geographical concentration or dispersion of firms for different areas at the same particular distance, usually as effective measures as a radius on a map [Marcon and Puech, 2009].

4

Estimation and Results

4.1 Bogotá

Bogotá is the most important economy in Colombia, it represents 26% of Colombian Gross Domestic Product (GDP) -66.7 million dollars-, and its product is above of small economies in Latin America -e. g. Uruguay or El Salvador- and many important cities of the region like Brasilia, Caracas, or Lima. With a population of approximately seven million people and an area of four hundred square kilometers, it is the country's biggest city.

Until 2008, Bogotá's product grew continually by eight consecutive years around 4.7% annual average, motivated by the services, industry, and construction, which represented 98% of the city's production, about 78%, 15%, and 5% respectively. The predominant size of firms on Bogota's economy is micro with 87% of the total, followed by the small and medium firms, with 11% [Camara de Comercio, 2009].

The land use in Bogotá is ruled by law providing order to the economic activity and offering different urban conditions for production for each economic sector. However, the law does not promote the location of a specific sector neither helps to consolidate an activity in a specific area. Rather, the law limits the use of land and imposes loads and benefits for doing these activities.

In the industry case, the law has forced large size firms to leave the urban perimeter if these companies cause environmental pressures. As a result, these firms have been locating in cities in the vicinity of Bogotá. Some critics to city´s planning law have said that the expulsion of these firms has been done in an premature way, and it will constrain the economic growth.

Contrary to the previous idea, our hypothesis is that although the large industrial firms cannot locate in the city, the small and medium firms impulse economic growth due to benefits of agglomeration. These benefits can be useful not only for them, but also for all the economic activities related to these specific industrial productions, such as forward and backward linkages.

4.2 Results

The hypothesis of agglomeration in Bogotá's manufacturing sector is evaluated estimating the Ripleys K function using the R software. The data used were obtained from thees DANE[3] Encuesta Anual Manufacturera[4] (EAM for its initials in Spanish), this survey gathers information from approximately 8000 industrial establishments at a nation level, and approximately 2500 at Bogotá's level. The distance between was estimated using the Euclidean distance between pairs of small and medium firms[5], sorted by sector using the four digit International Standard Industrial Classific ation[6]. We chose the five most important sectors by number of firms and workers, and analyze the agglomeration patterns from 2006 to 2008 (see tables 1 and 2).

Table 1. The number of employees by manufacturing sector in Bogota.

Sector Code	Total 2006	Total 2007	Total 2008
1810	10019	11368	12312
1921	1511	1678	1667
1926	500	487	476
1931	2066	1968	1870
2102	1744	1858	1908
2109	995	1026	985
2211	1382	1436	2257
2220	5171	4638	4338
2423	8320	7884	7615
2424	3859	3857	4496
2521	2784	3064	3576
2529	8004	8026	8293
2899	4154	4200	4062
2919	2020	2100	2419
3420	1608	1620	1639
3430	3414	3527	3139
3611	1581	1741	1626

Source: DANE-EAM

3 Departamento Administrativo Nacional de Estadística, National Department of Statistics.

4 Manufacturing yearly survey.

5 Firms with more than 10 employees and less than 200.

6 ISIC revision 3.1.

Table 2. The number of small and medium size rms by manufacturing sector in Bogota.

ACT06	2006 Small	2006 Medium	2007 Small	2007 Medium	2008 Small	2008 Medium
1810	86	116	103	138	112	136
1921	21	18	27	18	28	18
1926	13	6	14	6	15	4
1931	16	22	13	20	11	22
2102	24	24	26	26	26	28
2109	19	6	19	8	20	6
2211	19	18	18	22	26	28
2220	62	48	72	44	67	48
2423	44	92	42	86	43	102
2424	23	46	29	44	32	54
2521	25	28	28	32	34	36
2529	71	98	78	94	85	100
2899	50	46	52	46	57	44
2919	27	30	26	30	29	34
3420	7	22	7	22	4	26
3430	24	40	22	40	23	38
3611	32	16	36	16	37	16

Source: DANE-EAM

The information was georeferenced in a point map, using the production plant address, and distinguishing for size of firms. The map of points is posted on an administrative map of sub-areas called Unidades the planeamiento zonal (UPZ for its initials in Spanish), that segment city area in specific areas and land uses.

The estimated K function is compared with a theoretical distribution for each sector, and was done with 200 permutations simulated for a random location. Then a 95% confidence interval was made for proving the null hypothesis of randomness in the locational pattern by firms in the same industry. Following [Kosfeld et al., 2009] the decision rules for localization patterns are:

- If the estimated K-function is in the confidence interval, the hypothesis of random location is not rejected at distance *r*.
- If the estimated K-function is above the upper limit of confidence interval, there is evidence of agglomeration of firms in specific industry at distance *r*.
- If the estimated K-function is below the lower limit of confidence interval, there is evidence of dispersion of firms in specific industry at distance *r*.

4.3 Sector analysis

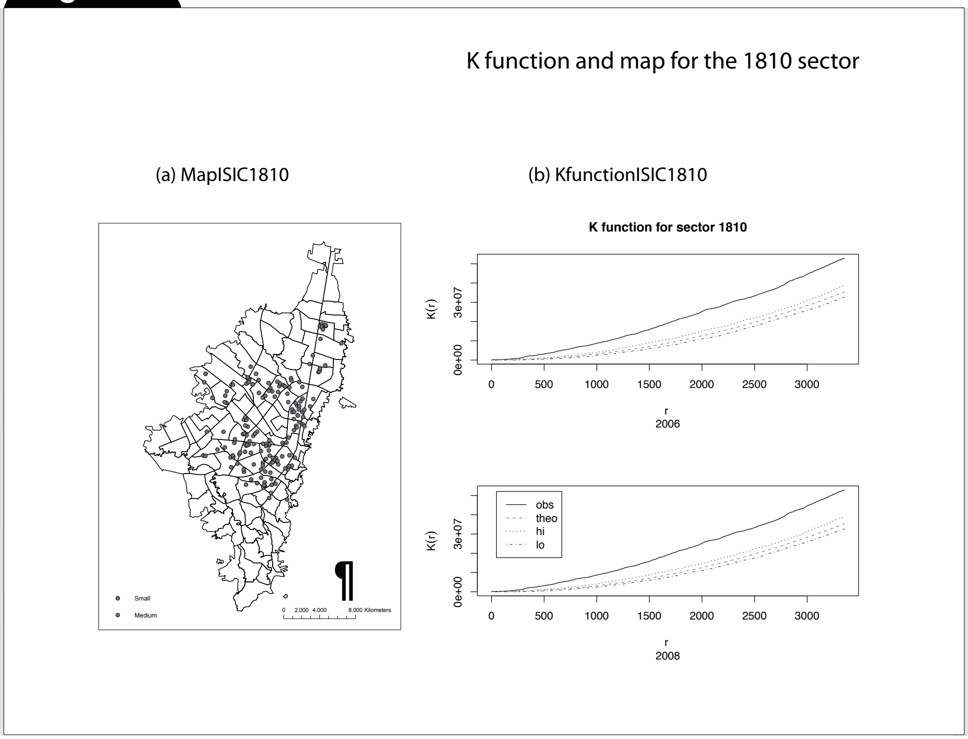
The industrial subsector with the biggest number of firms in Bogotá is specialized in "Manufacture of wearing apparel, except fur apparel" and coded 1810 (see table 3). The spatial distribution of the firms throughout the city that can be observed in figure 1 displays the presence of strong agglomeration at short distance. The map of the sector exhibits the existence of two established zones that cluster the majority of these firms.

Table 3. The amount of small and medium size rms by manufacturing sector in Bogota.

ISIC 3.1	ISIC 3.1 TITLE
1810	Manufacture of wearing apparel, except fur apparel
1920	Manufacture of footwear
2102	Manufacture of corrugated paper and paperboard and of containers of paper and paperboard
2109	Manufacture of other articles of paper and paperboard
2211	Publishing of books, brochures and other publications
2212	Publishing of newspapers, journals and periodicals
2221	Printing
2222	Service activities related to printing
2423	Manufacture of pharmaceuticals, medicinal chemicals and botanical products
2424	Manufacture of soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations
2520	Manufacture of plastics products
2899	Manufacture of other fabricated metal products n.e.c.
2919	Manufacture of other general purpose machinery
3420	Manufacture of bodies (coachwork) for motor vehicles manufacture of trailers and semi trailers
3430	Manufacture of parts and accessories for motor vehicles and their engines
3610	Manufacture of furniture

Source: DANE-EAM

Figure 1



Source: based upon author main results.

For the firms belonging to this sector the authors would expect some dispersion since they are small and medium size and the settings required, but the results show that these firms are gathered across Bogotá.

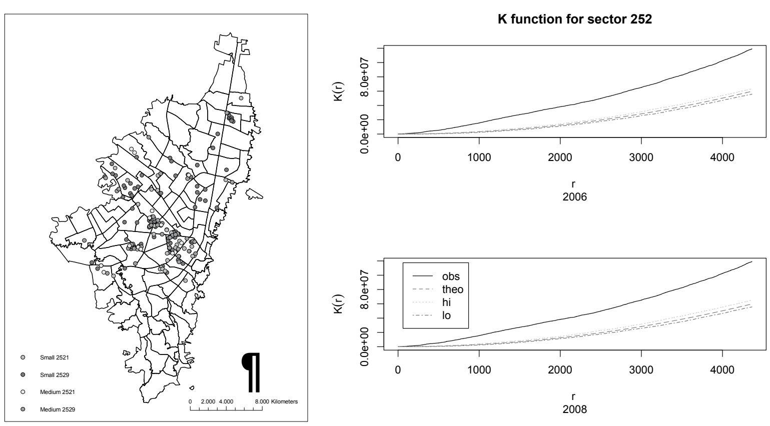
The subsector 252 classified as "Manufacture of plastics products" observed in figure 2 shows the presence of a cluster of large magnitude. This is confirmed by the K function analysis also in figure 2. It is important to highlight the development of two smaller clusters inside the city, one on the north area and another on the southwest part of the city.

The subsectors 3420 and 3430 labeled as "Manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semi-trailers" and "Manufacture of parts and accessories for motor vehicles and their engines" are located in a broad cluster as can be observed on figure 3. The K function shows that at 300 meters the agglomeration is set.

Figure 2

K function and map for the 252 sector

(a) MapISIC2520 (b) KfunctionISIC2520

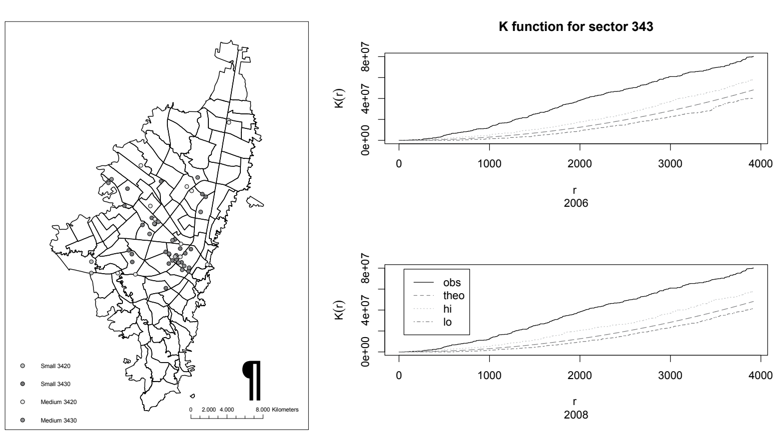


Source: based upon author main results.

Figure 3

K function and map for the 3420-3430 sector

(a) Map ISIC3420-3430 (b) Kfunction ISIC3420-3430

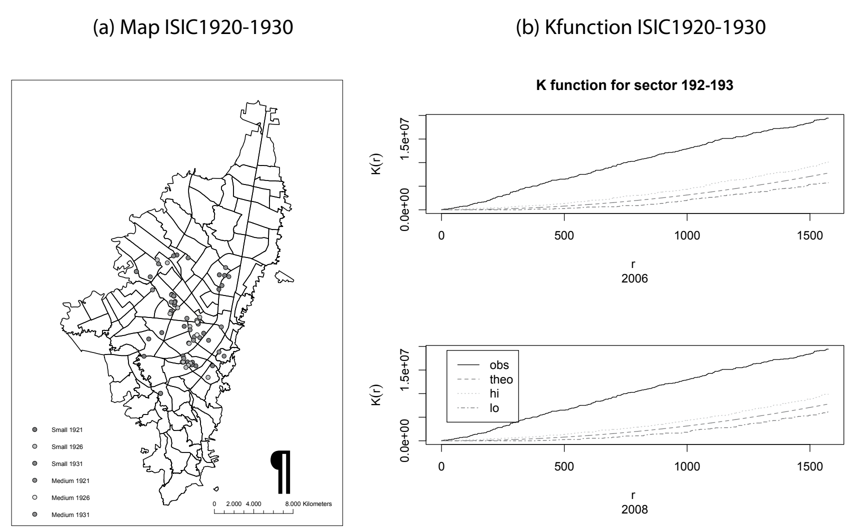


Source: based upon author main results.

The subsectors 1920 and 1930 labeled as “Manufacture of footwear” and “Manufacture of other leather products” are viewed on figure 4. These firms are traditionally gathered at the south part of the city and also newly developed clusters are in the central and west part of the city. The K function confirms that these three clusters are zones of strong spatial association because of the small distance that separates them.

Figure 4

K function and map for the 1920 and 1930 sectors

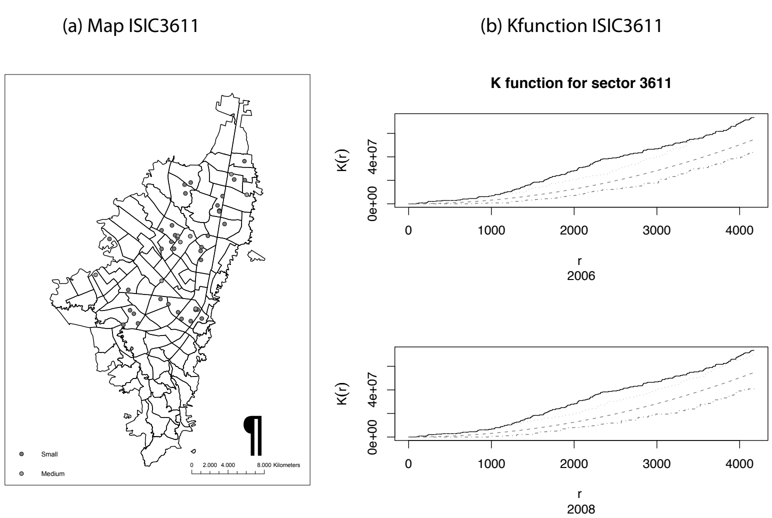


Source: based upon author main results.

A different dynamic is observed in sector 3611 identified as "Manufacture of furniture"; this sector spatially observed in figure 5 does not show a spatial agglomeration. The K function does not reject the randomness hypothesis of location pattern as opposed to the expected result. This is due to the fact that the survey does not include firms with less than 11 workers and this sector seems to be decreasing the firms` size.

Figure 5

K function and map for the 3611 sectors



Source: DANE-EAM

5

Conclusions

The previous analysis shows the presence of strong agglomeration for the principal industrial subsectors in Bogotá for small and medium size firms. The industrial subsectors analyzed exhibit established clusters. The observed clusters for the different subsectors are located in distinctive areas across the city. This leads us to think about different specialization areas. The development of a specialized cluster for the wearing apparel and plastics subsectors in the north of the city, and another on the west side of the city.

Almost all the subsectors that display agglomeration do not use skilled labor in a large scale, with the exception of the manufacture of chemical and pharmaceutical products. This explains that the agglomeration does not come from knowledge spillovers but from learning by doing and needs of provision or distribution. This channel seems to be strong in the manufacturers of footwear and leather products and plastic products. On the other hand, the learning by doing influences the wearing apparel manufacturers.

The period of time chosen for the sample featured good economic conditions and sustained growth in the Colombian economy. Due to these conditions, the subsectors demonstrated a reinforcement of the clusters in Bogotá.

6

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