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Kyu Sik Lee

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SYMPOSIUM ON URBANIZATION AND DEVELOPMENT

Intra-urban Location of Manufacturing Employment in Colombia[1]

KYU SIK LEE

Urban and Regional Economics Division, Development Economics Department, The World Bank, Washington, D.C. 20433

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This paper describes the spatial distribution of manufacturing employment in Bogota and analyzes the changes in the location patterns over the 1970–1975 period using industrial directory data. The analysis shows strong evidence of the spatial decentralization of manufacturing employment owing to a steady movement of firms outward from central areas; new large firms with more than 100 employees tend to locate near the periphery while the births of small firms tend to take place near the center. Measures of concentration indicate an increasing dispersion of manufacturing establishments during the period.

1. INTRODUCTION

Changes in the patterns of intra-urban location of manufacturing employment have been fairly well documented for cities in developed countries, particularly for large cities in the U.S. and U.K.,[2] where the decentralization of manufacturing employment has been observed for the past several decades.[3] Comparable studies for rapidly growing cities in less developed countries (LDCs), however, are rare. The location of employment tends to influence residential locations and sets the basis for the overall development patterns in an urban area. As the first step in a continuing research effort, this paper presents findings for Bogota, Co-

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[2]A comprehensive review of the literature on intra-urban manufacturing location can be found in Kemper (1973, Chap. 2); also, Struyk and James (1975) give a review of previous research related with this paper.

[3]For example, Hoover and Vernon (1959), Leone (1971), and Hamer (1975).

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lombia which also show a strong decentralization of manufacturing employment.

In the theoretical literature, the location behavior of a firm has been typically postulated in the neoclassical framework: given price gradients for rents and wages, transport costs of inputs and outputs, and the location of markets, a firm will tend to locate where it maximizes its profits.[4] In the recent empirical literature on employment location a popular approach has been to investigate not only the growth and decline of stationary (non-relocating) firms but also the location decision of newly established firms and relocating firms, and analyze changes in the location patterns at the margin.

Such empirical analyses require micro establishment data. Since the 1970 Economic Census, the National Statistics Department (DANE) of Colombia has been updating its annual industrial directory files which provide information on individual establishment operations including location, production, sales, and input uses.[5]

These data for the 1970–1975 period revealed a strong trend of decentralization of manufacturing employment.[6] To fully exploit the data content we did the analysis by the location tenure of firms, i.e., newly established (births), defunct (deaths), relocating (movers), and stationary (mature) firms. This amounts to decomposing changes in the stock of employment by the flows of births and deaths, relocation of jobs, and stationary growth and decline of employment.[7] The location of births and the destination of movers are particularly important for understanding the location dynamics of employment and predicting the future spatial structure of an urban area.

2. OVERVIEW OF MANUFACTURING EMPLOYMENT IN BOGOTA AND CALI: COMPARISONS WITH U.S. CITIES

According to a 1977 household survey,[8] in both Bogota and Cali, about 37% of the population were in the labor force: more than one million people were employed in Bogota while over a third of a million worked in Cali. Manufacturing jobs accounted for 25% of employment in Bogota and 30% in Cali. This share was the largest among all sectors in Cali, while in Bogota, it was second only to the services sector which had 32% of the

[4]See Alonso (1967), Mills (1972), and Ingram (1977).

[5]This data set is very similar to the Dun and Bradstreet Market Identifier (DMI) data in the U.S., which have been used in recent employment location studies for U.S. cities. See Leone (1971), Schmenner (1973 and 1981), Kemper (1973), and Struyk and James (1975). These files, however, include only establishments with 10 or more employees. This group accounts for more than 70% of total manufacturing employment in Bogota.

[6]This paper examines Cali as well as Bogota, but presents details for Bogota.

[7]This approach was also used by Leone, Schmenner, Struyk and James, and Cameron (1973).

[8]Published in *DANE Statist. Bull.*, No. 309, April 1977.

TABLE 1

Manufacturing Firm Size and Employment Distribution: Comparison of Bogota and Cali with U.S. cities

Size	Bogota		Cali		Washington, D.C.		Boston		Chicago		Los Angeles	
(persons)	%	cumm.	%	cumm.	%	cumm.	%	cumm.	%	cumm.	%	cumm.
					A. Firm size distribution[a]							
Less than 20[b]	57.55	57.55	55.25	55.25	59.11	59.11	50.39	50.39	46.89	46.89	53.03	53.03
20–49	24.17	81.72	22.45	77.70	24.53	83.64	25.08	75.47	24.06	70.95	24.48	77.51
50–99	10.11	91.83	11.95	89.65	8.88	92.52	12.93	88.40	11.60	82.55	11.18	88.69
100–499	7.43	99.26	9.33	98.98	6.54	99.06	10.05	98.45	14.61	97.16	9.84	98.53
500 or more	0.75	100.00	1.02	100.00	0.93	100.00	1.56	100.00	2.84	100.00	1.46	100.00
					B. Employment distribution[a]							
less that 20[b]	14.25	14.25	10.78	10.78	12.17	12.17	7.57	7.57	4.95	4.95	8.07	8.07
20–49	18.26	32.51	12.71	23.49	17.47	29.64	12.28	19.85	8.37	13.32	13.48	21.55
50–99	17.31	49.82	15.79	39.28	13.63	43.27	13.92	33.77	9.00	22.32	12.40	33.95
100–499	35.74	85.56	36.32	75.60	31.20	74.47	31.15	64.92	33.42	55.74	30.79	64.74
500 or more	14.45	100.00	24.39	100.00	25.54	100.00	35.08	100.00	44.26	100.00	35.25	100.00
					C. Average firm size (persons)							
less than 20		9.95		10.07		9.07		9.78		9.60		9.53
20–49		30.35		29.21		31.35		31.86		31.57		34.48
50–99		64.80		68.12		67.61		70.05		70.46		69.47
100–499		193.34		200.81		210.00		201.78		207.66		195.87
500 or more		771.63		1233.00		1,203.50		1,465.40		1,416.58		1,509.07
Total		40.18		51.58		44.04		65.07		90.80		62.62
(1,000 persons)												
Population[c]		3,453		1,057		2,862		2,754		6,978		7,041
Total employment[c]		1,157		351		1,110		1,098		2,503		2,596
Mfg. employment[c]		291		106		67		262		782		719
Mfg. empl. share (%)		(25.16)		(30.20)		(6.04)		(23.87)		(31.24)		(27.70)

Sources: Figures for U.S. cities are from Gregory K. Ingram, "Reductions in Auto Use from Carpools and Improved Transit," Harvard University, October, 1976; they are derived from *County Business Patterns*, 1973, and data on journey to work (Table 2) of the 1970 U.S. Census.

[a]1970 for Bogota and Cali; and 1973 for U.S. cities. All U.S. figures are for central city.

[b]For Bogota and Cali, this category covers 5–19; and for U.S. cities, 4–19.

[c]1977 estimate for the Special District of Bogota and Cali; 1970 U.S. census SMSA figures for U.S. cities.

city's employment. Large U.S. cities such as Boston, Chicago, and Los Angeles also have about 25–30% of employment in manufacturing.

The firm size distribution in Bogota, compared in Table 1, is not much different from that of Cali except that Cali has proportionally more firms of the largest size. The firm size distribution of Bogota looks much like that of Washington, D.C., although the latter has only a small amount of manufacturing employment. Cali, in contrast, resembles Los Angeles in terms of the firm size distribution as well as its share of manufacturing employment; Cali, however, has a smaller proportion of employment in the 500 or more category than Los Angeles. Moreover, in this last category,

TABLE 2

Birth, Death, and Relocation Rates in Bogota, Cali, and U.S. Cities

	Births				Deaths				Movers[d]			
	Establishments		Employment		Establishments		Employment		Establishments		Employment	
	% of base	Annual rate	% of base	Annual rate	% of base	Annual rate	% of base	Annual rate	% of base	Annual rate	% of base	Annual rate
Cleveland[a]	9.97	3.22	2.59	0.86	14.07	4.49	7.75	2.52	13.83	4.41	5.77	1.89
Minneapolis–St. Paul[a]	12.29	3.94	6.17	2.02	18.00	5.67	11.25	3.62	15.93	5.05	8.28	2.69
Boston[a]	6.10	1.99	1.30	0.43	13.40	4.28	8.00	2.60	9.80	3.17	4.70	1.54
Phoenix[a]	24.40	7.55	12.10	3.88	20.20	6.32	5.30	1.74	8.90	2.88	4.70	1.54
New York[b]	10.21	4.98	3.95	1.96	7.56	3.71	3.55	1.76	11.45	5.57	1.24	0.62
Bogota[c]	52.38	8.79	31.96	5.70	27.01	4.90	12.61	2.40	19.12	3.56	16.59	3.12
Cali[c]	43.13	7.44	24.48	4.48	26.88	4.88	11.27	2.16	18.33	3.42	10.40	2.00

[a]From R. Struyk and F. James, "Intrametropolitan Employment Location," Lexington Books, Lexington, Mass., 1975; covered 1965–1968 period (1965 was the base year).

[b]From R. Leone, "Location of Manufacturing Activity in the New York Metropolitan Area," Yale University, 1971; covered 1967–1969 period (1967 was the base year).

[c]The period covered was 1970–1975; 1970 was used as the base year. The base year figures can be seen in Lee (1978).

[d]In the case of Bogota, the figures include establishments which moved at least to another *seccion* changing DANE's six-digit zone code; in the case of Cali the figures include establishments which moved at least to another *barrio* changing the first four digits of DANE's zone code. Including the moves within the same *seccion*, the annual relocation rate of establishments was 5.12% for Bogota and 4.28% for Cali.

the average firm size in Bogota is only about half of those in large U.S. cities.

In terms of employment dynamics, Table 2 indicates that Colombian cities are somewhat different from U.S. cities. At an annual rate of 8.8%, the birth rate of firms[9] in Bogota is higher than that of all five U.S. cities. Phoenix, with a birth rate of 7.6%, comes closest to Bogota's and is slightly higher than Cali's. The average death rate in Bogota, as well as in Cali, is comparable to that of Cleveland, Minneapolis, and Boston. It should be noted that the birth rate is greater than the death rate for Bogota, Cali, Phoenix, and New York;[10] the opposite is true in Boston, Minneapolis, and Cleveland.

[9]This may include other than genuine births; for example, the birth category may include those moving into the area.

[10]This was true for New York in the late sixties. The situation may have been reversed by now. Both studies for U.S. cities, cited in Table 2, covered a two- to three-year interval in the late sixties. A study of such a short period may reflect only what happened in that particular portion of business cycle. In this respect, our data set is somewhat more attractive because it covers a six-year period.

In all cases, the activity rates in terms of establishments are greater than the rates based on employment. This indicates that the marginal firms are small ones which have a greater propensity to move, to start up and close down business. During 1970–1975, nearly 60% of firm births and deaths were in the 10–24 person category in Bogota as well as in Cali; moreover, the median age of establishments, as of 1970, was 4.5 years in both cities. Small, young firms therefore seem to contribute significantly to the changes in employment distribution in Colombian cities.

3. SPATIAL DISTRIBUTION OF EMPLOYMENT: EVIDENCE OF DECENTRALIZATION

DANE's zone system divides Bogota into 38 *comunas*. To analyze changes in employment location patterns, we devised two zone systems by aggregating *comunas* into six "rings," and eight "radial sectors" (see Fig. 1). Tabulations of employment using the six rings, reported in Table 3, provide strong evidence of decentralization of manufacturing employment in Bogota: Ring 1 experienced an absolute decline in employment; moving out from the central business district (CBD), we observe an accelerating employment growth which reaches an annual rate of 16% in Ring 5.

The system of eight radial sectors follows the patterns of land use specialization in Bogota. The "industrial corridor," which bisects the city into the north and the south, is Radial Sectors IV and V. The residential north is Sector VIII, and the residential south is Sector II. The residual southwest area is labeled Sector III; the residual northwest is further

TABLE 3
Distribution of Manufacturing Employment[a] by Ring, Bogota, 1970–1975

	1970		1975		
Ring	Persons	%	Persons	%	Annual average growth rate (%)
1(CBD)	4,538	5.60	4,102	3.47	– 2.00
2	11,767	14.53	14,898	12.59	4.83
3	34,351	42.42	47,858	40.44	6.86
4	18,112	22.37	25,958	21.94	7.46
5	11,548	14.26	24,047	20.32	15.80
6	391	0.48	729	0.62	13.27
n.a.	266	0.33	741	0.63	—
Total	80,973	100.00	118,333	100.00	7.88

Data source: DANE Industrial Directory Files.
[a] Establishments with 10 or more employees.

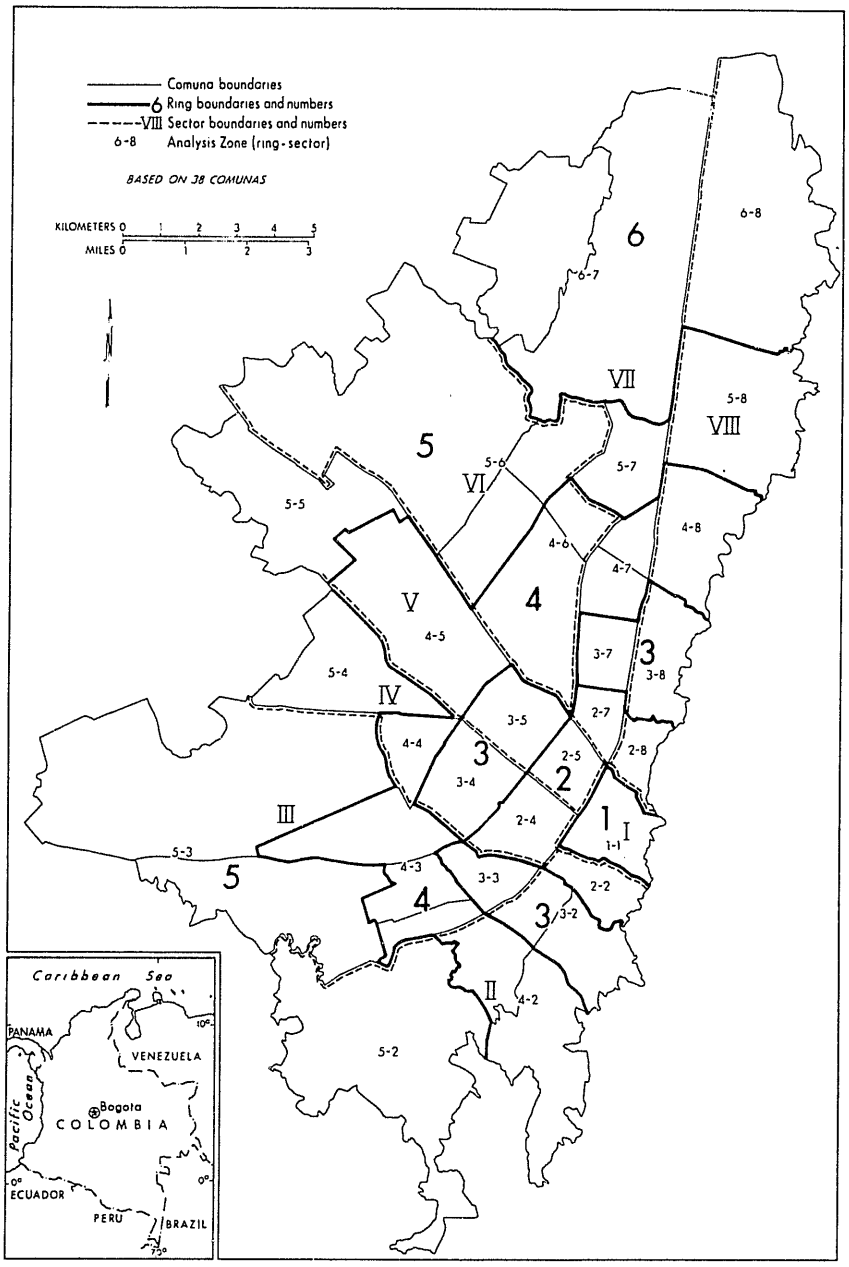


FIG. 1. The zone system: Bogota. (This map has been prepared by the World Bank's staff. The denominations used and the boundaries shown on this map do not imply, on the part of the World Bank and its affiliates, any judgment on the legal status of any territory or any endorsement or acceptance of such boundaries.)

divided into Sector VI, containing the airport, and Sector VII, which includes the "commercial corridor" of *Chapinero* areas and the residential northwest.

As Table 4 shows, manufacturing employment growth was lowest in two residential sectors (II and VIII). In addition, employment growth in Sectors IV and V ("industrial corridor") was slightly lower than the overall growth rate. These sectors had lower than average employment growth, thus reducing their relative shares of manufacturing employment during the period. The "residual" sectors (III, VI, and VII), in contrast, increased their relative shares of manufacturing employment. Evidence for the decentralization of employment from the industrial corridor to the non-residential sectors is also supported by the extremely high employment growth in Sector III (15%) and Sector VII (12%).

4. COMPOSITION OF CHANGES IN SPATIAL DISTRIBUTION OF EMPLOYMENT: THE INCUBATOR HYPOTHESIS

To study changes in employment levels over time and space, we created a master file with the following categories of firms: (1) mature firms—those that appeared in all six annual directories with the same address; (2) births —those that appeared for the first time in any year during 1971–1975 and

TABLE 4

Distribution of Manufacturing Employment[a] by Radial Sector, Bogota, 1970–1975

Radial sector		1970 Persons	1970 %	1975 Persons	1975 %	Annual average growth rate (%)
I	CBD	4,538	5.60	4,102	3.47	− 2.00
II	South	2,451	3.03	3,218	2.72	5.60
III	Southwest	6,255	7.72	12,741	10.77	15.29
IV, V	Industrial corridor	57,833	71.42	84,362	71.29	7.84
VI	Airport	3,532	4.36	5,333	4.51	8.59
VII	Northwest	1,960	2.42	3,493	2.95	12.25
VIII	North	4,138	5.11	4,343	3.67	0.97
	n.a.	266	0.33	741	0.63	—
	Total	80,973	100.00	118,333	100.00	7.88

Data source: DANE Industrial Directory Files.

[a] Establishments with 10 or more employees.

kept the same address; (3) deaths—those that dissappeared from the directory during 1971–1975 after having kept the same address; and (4) movers—those that relocated within Bogota during 1971–1975, including births and deaths that changed the address during the period.

As indicated earlier, changes in spatial patterns of employment can best be understood by examining the location behavior of establishments by their location tenure. In Table 5, we find that the 4.7% growth of employment in mature firms was much lower than the overall growth rate of 7.9%

TABLE 5

Composition of Changes in Manufacturing Employment[a] by Ring, Bogota, 1970–1975

	Mature[b]				Births[b]		Deaths[b]		Movers			
	1970		1975						At Origin		At Destination	
Ring	Persons	%	Persons	%	Persons	%	Persons	%	Persons	%	Persons	%
1(CBD)	2,364	3.95	2,828	3.76	1,011	4.16	581	6.24	1,659	14.80	433	3.22
2	7,136	11.92	8,211	10.93	4,310	17.73	1,701	18.28	2,726	24.32	1,772	13.19
3	26,291	43.93	32,807	43.67	8,393	34.52	3,663	39.36	4,689	41.82	4,535	33.77
4	14,591	24.38	17,701	23.56	4,554	18.73	1,611	17.31	1,697	15.14	3,273	24.37
5	9,149	15.29	13,035	17.35	5,332	21.93	1,677	18.02	358	3.19	3,351	24.95
6	119	0.20	29	0.04	487	2.00	44	0.47	82	0.73	66	0.49
n.a.	191	0.32	519	0.69	224	0.92	29	0.31	—	—	—	—
Total	59,841	100.00	75,130	100.00	24,311[c]	100.00	9,306[d]	100.00	11,211	100.00	13,430	100.00

Summary Statistics

Ring	Annual stationary growth rate (%)	Annual birth rate (%)[e]	Annual death rate (%)[e]	Origin/destination ratio of movers
1(CBD)	3.65	4.10	2.44	3.83
2	2.85	6.44	2.74	1.54
3	4.53	4.47	2.05	1.03
4	3.94	4.59	1.72	0.52
5	7.34	7.89	2.75	0.11
6	—	17.56	2.16	1.24
Total	4.66	5.39	2.20	0.83

Data source: DANE Industrial Directory Files.

[a]Excluded those establishments with less than 10 employees, that appeared only for one year in the directory. The accounting identity between (1) the change in stock of employment in Table 3 and (2) the sum of flows and stationary growth in Table 5 does not hold mainly because of the omission of 135 firms (out of 2,629) which could not be classified into the four location tenure categories. See Lee (1978) for details.

[b]Excluding movers.

[c]At birth.

[d]In 1970.

[e]Annual average rate based on 1970 manufacturing employment (Table 3).

(Table 4).[11] While mature firms in Ring 5 grew at a rate close to the overall average, those in the CBD and Ring 2 grew more slowly than those in the other rings. The lowest growth of mature firms in Ring 2 with fairly high employment concentration may indicate the existence of capacity constraint. In addition, we observe that nearly 60% more jobs were created by newly founded firms than by mature ones. In all rings, the number of jobs created by births was more than the number resulting from the growth of mature firms; in Ring 2, the former was four times larger than the latter.

It is striking that Ring 2 has the lowest growth of mature firms but is also a high birth area; its annual birth rate is higher than the industry average. Moreover, many firms start business in Ring 2 and then move out of this area. This may be evidence for the modified case[12] of the incubator hypothesis, which states that small, new firms tend to locate in centralized areas that provide essential services such as production space and financial services. Based on the criteria similar to those used by Struyk and James (1975), the incubator hypothesis is supported in Ring 2 as follows: the area's percentage share of employment by births (18%) is greater than its share of base year employment (15% in Table 3). This is also true for Rings 5 and 6, but these areas are disqualified from being an "incubation area" because their new firms are not small. Ring 5 is impressive in terms of attracting new firms and movers; the annual birth rate was highest (except for Ring 6 which had a small employment base), and the inflow of jobs into Ring 5 was also more than ten times the outflow. It should be noted that the percentage distribution of births across the rings was very similar to that of deaths.

To test the incubator hypothesis more specifically, we have defined 28 analysis zones by intersecting six rings with eight radial sectors (see Fig. 1);[13] we then determined as an incubation area those with the following characteristics: (1) the area has a high concentration of births; (2) the area's percentage share of employment by births is greater than the corresponding share of base year employment; and (3) the average firm size of births is small (i.e., about 25 persons). The areas shown in Table 6 had a high concentration of births; it is interesting to find that in the CBD and the industrial corridor in Rings 3 and 4 the share of employment by births was smaller than the share of base year employment. On the other

[11]Even though one might expect that the 1974 recession affected the growth of mature firms, this would not have resulted in a difference of such a magnitude in the employment growth rate.

[12]Hoover and Vernon (1959) were concerned with the incubation phenomenon in the city center. Struyk and James, however, "modified" the hypothesis by extending it to other centralized areas and traditional manufacturing districts.

[13]An analysis zone is identified by a two-digit number: the first digit refers to the ring and the second refers to the sector.

TABLE 6

Selected Analysis Zones and "Incubation" Areas in Bogota

	Employment share (%)		Ratio	Average firm size (persons)	
Analysis zone (AZ)	1970 Base (1)	Births (2)	(2)/(1)	1970 Base	Births
CBD (AZ 11)	5.60	4.16*	0.74	32.0	37.4
Ind. corridor (AZ 24, 25)	11.11	15.07*	1.36*	36.0	27.5*
Northwest[a] (AZ 27, 37, 47)	2.16	5.94*	2.64*	21.3	20.3*
Ind. corridor (AZ 34, 35)	37.80	26.47*	0.70	61.3	32.2
Ind. corridor (AZ 44, 45, 54)	22.50	15.66*	0.70	94.4	50.8
Southwest[b] (AZ 53)	3.20	5.85*	1.83*	99.6	94.8
Ind. corridor[c] (AZ 55)	0.01	4.24*	424.00*	11.0	114.4
Subtotal	82.38	77.39	0.93	55.9	35.5
Total (Bogota)	100.00	100.00	1.00	55.1	34.1

Note: * indicates passing a criterion to be an "incubation area."
Data sources: DANE Industrial Directory files.
[a]This zone contains *Chapinero* commercial area.
[b]Includes Bosa.
[c]Includes Fontibon.

hand, in the industrial corridor in Ring 5 and in Ring 2, the employment share by births was greater than the corresponding share of base year employment. In Ring 5, however, the average firm size of births was about 100 persons, indicating that the birth of large firms indeed occurs near the periphery. Only the industrial corridor in Ring 2 and the northwest (*Chapinero*) area therefore pass all three criteria for an "incubation area."

To examine the direction of relocating firms, Table 7 considers six subareas, defined by the CBD, three segments of the industrial corridor, the north (Sectors VI, VII, and VIII) and the south (Sectors II and III).[14] For these six subareas, a matrix of origin and destination was constructed in terms of the number of relocating establishments (Table 7). Nearly 40% of the movers relocated within their same subareas; 37 firms (13%) moved within analysis zones (AZ) 34 and 35 alone. Only one-third of these 37 firms had more than 50 employees while about a half of the firms that moved from Ring 3 to Rings 4 and 5 in the industrial corridor were large size firms; long-distance movers tend to be large size firms.[15]

As expected, the CBD experienced a net loss of firms: 30 moved out of the CBD while only 4 moved into that area. Rings 2 and 3 in the industrial corridor and the north also lost more establishments than they gained, while the reverse happened in the south and in Rings 4 and 5, which attracted the largest number of movers: 52 establishments moved into that

[14]See Fig. 1.
[15]This is consistent with similar findings on Chicago by Moses and Williamson (1967).

TABLE 7
Origin and Destination of Movers,[a], Bogota
(Number of Firms)

Origin	Destination						
	CBD[b]	AZ24, 25	AZ34, 35	AZ44, 45, 54, 55	North	South	Total
CBD	12	7	10	3	6	4	42
	(2)[c]	(1)	(3)	(1)	(1)	(1)	(9)
AZ24, 25	2	11	18	5	3	6	45
	(0)	(0)	(1)	(2)	(1)	(1)	(5)
AZ34, 35	0	12	37	26	6	7	88
		(4)	(12)	(13)	(1)	(4)	(34)
AZ44, 45, 54, 55	0	2	6	10	4	2	24
		(1)	(2)	(4)	(2)	(2)	(11)
North	2	2	7	13	29	4	57
	(1)	(0)	(2)	(5)	(2)	(1)	(10)
South	0	3	4	5	3	10	25
		(1)	(1)	(1)	(1)	(3)	(7)
Total	16	37	82	62	51	33	281
	(3)	(7)	(21)	(26)	(7)	(11)	(75)

Data source: DANE Industrial Directory files.
[a] Establishments with 10 or more employees.
[b] For definition of zones, see Fig 1. AZ refers to analysis zone.
[c] The number of establishments with 50 or more employees at destination.

area while only 14 moved out. Among the six subareas, a relatively large number of firms relocated from the CBD to Rings 2 and 3 in the industrial corridor, from Ring 2 to Ring 3, from Ring 3 to Rings 4 and 5, and also from the north to Rings 4 and 5 of the industrial corridor; only a few firms relocated from the CBD to as far as Rings 4 and 5. The fact that a large number of firms are moving out of Ring 2 is consistent with the incubator hypothesis tested above.

5. SPATIAL CONCENTRATION OF INDUSTRIES: A TEST OF AGGLOMERATION ECONOMIES

The analyses presented above revealed changes in employment location for all manufacturing. Such patterns will, however, vary across industries since the location decisions of individual firms will depend partly on the characteristics of their parent industries. After describing the spatial concentration of industries in Bogota, we will then examine to what extent the concentration of industries in particular locations might influence the location decisions of firms. The hypothesis is that in the presence of

TABLE 8

Distribution of Manufacturing Employment[a] by Ring and Industry, Bogota, 1970, 1975 (%)

	Food (311)[b]		Beverages (313)		Textile (321)		Apparel (322)		Furniture (332)		Printing (342)	
Ring	1970	1975	1970	1975	1970	1975	1970	1975	1970	1975	1970	1975
1	5.0	2.9	—	0.5	2.7	1.1	18.5	9.5	3.1	2.0	28.0	23.6
2	15.2	15.5	30.9	4.3	15.4	11.0	17.2	23.2	19.6	5.1	15.4	10.7
3	62.9	53.8	54.2	52.9	46.1	44.0	49.6	46.7	36.8	48.6	29.6	38.7
4	5.0	9.2	12.7	16.7	25.8	25.9	3.3	12.5	32.3	31.7	22.6	20.2
5	11.8	18.1	2.2	25.6	9.2	17.2	11.4	8.1	8.2	12.6	4.4	5.9
6	—	0.5	—	—	0.8	0.3	—	—	—	—	—	1.1
n.a.	0.2	—	—	—	—	0.7	—	0.1	—	—	—	—
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

	Other chemical (352)		Plastic (356)		Fabr. metal (381)		Non-electric machine (382)		Elec. mach. (383)		Transport equipment (384)	
Ring	1970	1975	1970	1975	1970	1975	1970	1975	1970	1975	1970	1975
1	0.3	0.2	1.1	0.4	8.2	0.1	2.7	1.2	4.4	0.6	1.2	0.1
2	17.5	14.6	4.3	5.3	12.5	13.2	5.8	7.4	16.5	11.0	7.3	8.3
3	38.8	34.5	26.6	30.8	33.9	34.5	42.6	36.9	33.2	48.0	39.7	28.5
4	17.7	19.3	13.4	12.1	32.3	33.2	28.1	25.4	34.4	27.8	28.8	29.5
5	25.8	31.1	48.1	40.3	13.2	18.5	20.8	28.7	11.5	12.6	22.9	33.5
6	—	0.3	0.3	—	—	0.5	—	0.4	—	—	—	—
n.a.	—	—	6.2	11.1	—	—	—	—	—	—	—	—
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Data source: DANE Industrial Directory Files.

[a]Establishments with 10 or more employees.

[b]SIC code.

agglomeration economies, the location patterns of new firms will follow those of the parent industries.

The degree of employment concentration varies across industries in Bogota. Of the 29 three-digit industries, about 80% of the total employment was concentrated in the largest 12 industries.[16] As shown in Table 8, all industries except for the plastic industry had their highest concentration of employment in Ring 3 during the 1970–1975 period, as was the case for the total manufacturing. In six of these industries, the employment share in Ring 3 was higher than the industry average, but in most areas its decline during the period resulted in a greater dispersion of employment. In all twelve industries, there was a substantial degree of decentralization of employment.

[16]Each of these 12 industries had at least 3% of the total employment.

The durable industries shown in Table 8 maintained a large share of employment in Ring 4 as well as in Ring 3 during the period. In the case of the plastic industry, the employment share was highest in Ring 5. It should also be noted that, as in large U.S. cities, employment in the printing industry in Bogota is also concentrated in the CBD. Although there was a shift of employment in this industry to Ring 3, 24% of the printing industry's jobs were located in Ring 1 in 1975.

The above description is with respect to the distance from the city center. In order to measure the extent of industrial concentration around a centroid of industries, we have computed the "standard distance,"[17] using the following statistic:

$$d_j = \sqrt{\frac{\sum_i E_{ij}(x_i - \bar{x}_j)^2 + \sum_i E_{ij}(y_i - \bar{y}_j)^2}{\sum_i E_{ij}}}$$

where

$$\bar{x}_j = \frac{\sum_i E_{ij} x_i}{\sum_i E_{ij}}, \qquad \bar{y}_j = \frac{\sum_i E_{ij} y_i}{\sum_i E_{ij}};$$

E_{ij} = the number of employment in the jth industry in the ith area; (x_i, y_i) = the center of the ith area in terms of x,y coordinates; and $(\bar{x}_j, \bar{y}_j)$ = the location of centroid of the jth industry.

This formula measures a standardized distance, weighted by the number of jobs (or establishments), from subareas where jobs are located to the centroid of jobs in a particular industry. The value of standard distance will show the degree of concentration relative to the industry's centroid.

The standard distances are estimated for all manufacturing establishments for the six years from 1970 through 1975. Table 9 shows that the standard distances increased over time as average firm size increased, indicating the general tendency of greater industrial dispersion. We also find that the standard distances of small firms were consistently shorter than those of large firms. The differences in the orders of magnitudes, however, are too small to suggest any definite tendency for small firms to cluster in the presence of agglomeration economies.[18] Although we also computed estimates of standard distances at the three-digit level, they showed no consistent differences between small and large firms. Moreover,

[17] Isard (1960) had attributed its origin to Bachi (1957). (The expression of this measure appearing in Isard (1960), however, has an error.) The form of the squared standard distance is actually the same as that of the moment of inertia.

[18] Without having internal economies of scale, small firms need to share facilities and service inputs among themselves; therefore, they are expected to cluster together or locate near the center of the parent industry.

TABLE 9
Standard Distances of Establishments[a] by Firm Size, Bogota, 1970–1975

	Standard distance (km)			Average firm size[b] (persons)	Proportion of small firms[c] (%)
	Less than 25 persons	25 or more persons	All firms[b]		
1970	3.54	3.69	3.66	55.1	49.0
1971	3.65	3.70	3.72	57.3	47.3
1972	3.54	3.85	3.76	62.1	44.4
1973	3.83	4.02	3.97	60.8	45.4
1974	3.94	4.02	4.02	63.6	43.7
1975	4.01	4.04	4.06	64.7	42.7

Data source: DANE Industrial Directory Files.
[a]10 or more employees.
[b]All firms with 10 or more employees.
[c]Less than 25 category.

the values of standard distances for small firms tended to increase during the five-year period. This again confirms the general tendency for industries to disperse over time.

Table 10 reports the values of standard distances for the 12 leading industries in Bogota. First, we observe that the values of standard distances increased between 1970 and 1975 for all industries except textile, plastic, and electric machinery. These results support the general trend of increasing industrial dispersion, while having revealed some industries with increasing concentration.[19]

In Table 10, the location patterns of mature firms are compared with those of new (births) and defunct (deaths) firms. The standard distances of mature firms do not vary much across industries and their values are smaller than those of births for all industries reported except beverages and plastic. This implies that new firms locate differently than mature firms,[20] i.e., they tend to locate farther from the centroid of a given industry. This observation holds for the births of small establishments as well as large ones in most industries. It is possible that new firms are unable to compete against existing establishments for the limited space in the centralized location, or that additional space may not be available. Moreover, small new firms gain the advantage of agglomeration economies near the CBD, i.e., in the "incubation" area which does not coincide with the centroids of industries. Our findings in the previous section support

[19]Among those industries not reported in Table 10, the value of standard distance declined also for leather, industrial chemical, and "other manufacturing" industries.

[20]Similar results were obtained by Cameron (1973) for the Clydeside conurbation in Scotland, but his measure was a simple average distance from the core of the central city.

TABLE 10

Standard Distances of Establishments[a] by Firm Type for Selected Industries, Bogota, 1970–1975 (km)

SIC	Industry	Mature	Births: Small	Births: Large	Births: All[b]	Deaths	All: 1970	All: 1975
	Non-durable							
311	Food	3.04	4.78	5.66	5.18	3.97	3.22	3.97
313	Beverages	2.83	2.53	—	2.53	0.86	3.25	3.32
321	Textile	3.88	4.28	3.60	4.26	4.74	4.09	3.96
322	Apparel	2.96	3.74	3.74	3.81	3.89	3.31	3.58
352	Other chemical	3.36	4.91	5.78	5.37	4.73	3.33	4.25
	Durable							
332	Furniture	3.79	4.08	3.25	3.93	4.12	4.02	4.29
342	Printing	2.94	2.67	5.80	4.19	2.00	2.74	3.50
356	Plastic	3.48	2.89	3.63	3.25	5.97	3.98	3.01
381	Fabricated Metal	3.54	3.66	5.61	4.41	2.41	3.29	3.72
382	Non-electric Machinery	2.65	3.83	3.35	3.66	3.19	2.85	3.36
383	Electrical Machinery	2.67	2.62	2.54	2.65	3.55	2.94	2.83
384	Transportation Equipment	3.26	3.94	4.94	4.35	2.35	3.10	4.16

Data source: DANE Industrial Directory Files.

[a]Establishments with 10 or more employees.

[b]Small establishments have less than 25 employees.

this observation: Table 6 showed that the incidence of births relative to base year employment share was low in the centralized industrial districts (Rings 3 and 4 in the industrial corridor) where the concentration of manufacturing employment was highest.

The plastic, the beverages, and the electric machinery industries are the only cases where the standard distance of births was shorter than that of mature firms. Of the industries not reported in Table 10, this was also true for the leather, paper, instruments, and "other manufacturing" industries.[21] This can be interpreted as evidence for the presence of agglomeration economies in the sense that new firms tend to follow the location patterns

[21]These four industries together, however, had only 6% of total manufacturing employment in 1975.

of the stock of mature firms.[22] It is striking that the value of the standard distance of deaths was the largest for the plastic industry; this may indicate that the incidence of deaths was high for those firms that were located far away from the industry's cluster of firms.

As mentioned earlier, the standard distance of the textile industry decreased over time as did those of the plastic and the electric machinery industries. The standard distance of all firms in an industry will decrease whenever the standard distance of births is shorter than that of the stock of mature firms; i.e., the degree of concentration increases. It is then apparent that we observe the prevalence of agglomeration economies in the textile industry as well as the seven industries mentioned above, namely, the plastic products, beverages, electric machinery, leather, paper, instruments, and "other manufacturing" industries. These eight industries together, however, accounted for only 32% of the total manufacturing employment in 1975.

The standard distance as a measure of the degree of concentration does not show the possibility of multi-centers of employment. In order to discriminate such a possibility from the single-centeredness of employment, an "index of contiguity" has been constructed as follows. First, a measure of proximity (P) of the jth industry's employment to the sth subarea is defined in terms of employment (E) and distance (d) between subareas s and t:

$$P_{js} = \sum_{\substack{t \\ t \neq s}} \frac{E_{jt}}{d_{st}^2}, \qquad j = 1, 2, \ldots 12; s, t = 1, 2, \ldots 38,$$

where 38 *comunas* are used as subareas.

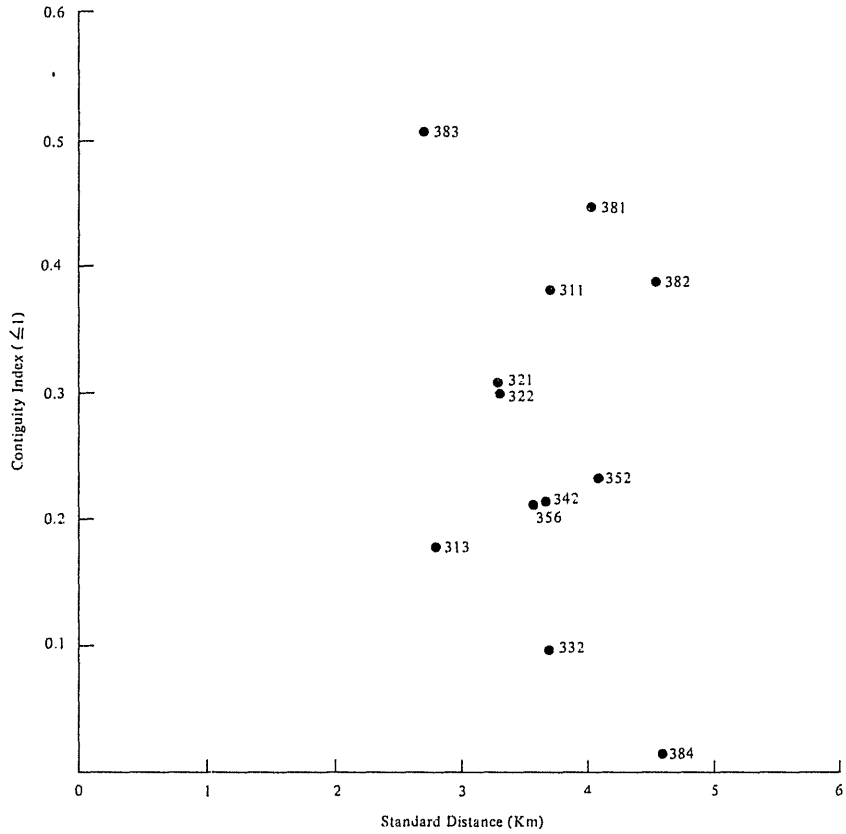
Thus, the value of P_{js} will be high when a large amount of the jth industry's employment is located in subareas near the sth area.

The contiguity index for the jth industry (C_j) is then defined as the correlation coefficient between P_{js} and E_{js} across all 38 subareas, namely,

$$C_j = C(P_{js}, E_{js}), \qquad \text{where } 0 \leq C_j \leq 1.$$

A high value of C_j means that when a subarea has a large (small) amount of the jth industry's employment, its surrounding subareas also have a large (small) amount of that industry's employment. The contiguity

[22] In the study of the Clydeside conurbation in Scotland, Cameron (1973) concluded that new plants tend to "replicate the pattern of their parent industries with regard to their access to the center." This was interpreted as "evidence for the existence of significant agglomerative forces that mold the locational advantages for manufacturing activity" as stated by Struyk and James (1975). Cameron's test was based on the rank correlation coefficient between the average distance from the city center of new firms and that of existing firms across 84 Minimum List Heading industries.



SIC codes: 311 = food, 313 = beverages, 321 = textile, 322 = apparel, 322 = furniture, 342 = printing, 352 = other chemical, 356 = plastic, 381 = fabricated metal, 382=non-electric machinery, 383 = electric machinery, 384 = transportation equipment

Data Source: DANE Industrial Directory Files.

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FIG. 2. Contiguity index and standard distance for manufacturing employment, Bogota, 1975.

index has been computed for the 12 major industries in Bogota for 1975, and their values are plotted against the corresponding values of the standard distances as shown in Fig. 2. Based on these two measures, the spatial characteristics of the employment distribution can be summarized as follows:

	Standard distance	
Contiguity index	Small	Large
High	Single-centered	Multi-centered
Low	Primate	Dispersed

It is possible that an industry with a high value of the contiguity index can have a large standard distance or a small one; the former represents a multi-centered case while the latter a single-centered one. An industry with a low value of the contiguity index tends to be widely dispersed if the standard distance is large; if small, the industry will be a primate case where most of its employment is located in a single subarea. Figure 2 shows that the contiguity index is inversely related with the standard distance, which indicates the single-centeredness of manufacturing employment in Bogota. Nevertheless, there is weak evidence of multi-centeredness for the fabricated metal and the non-electric machinery industries while the beverage industry has the primate characteristic.

6. SUMMARY OF FINDINGS AND CONCLUDING REMARKS

The main focus of this paper was on the spatial distribution of manufacturing employment and its changes over the period 1970–1975. In terms of birth, death, and relocation rates of manufacturing firms, we found a high degree of employment dynamics (i.e., changes at the margin) in both Bogota and Cali. The birth rate for firms in Bogota was higher than that for all five U.S. cities compared; only the rate in Phoenix, which was about the same as Cali, came close to Bogota's birth rate. As observed in large U.S. cities, the incidence of births and deaths in Bogota and Cali was concentrated in small establishments.

Our analysis shows strong evidence of the spatial decentralization of manufacturing employment in Bogota. While the central business district experienced a net loss of manufacturing jobs during 1970–1975, manufacturing employment grew at an accelerating rate with distance from the city center. We found a steady movement of jobs outward from central areas within as well as outside the industrial corridor. The outer rings of the southwest and northwest areas were especially attractive to new and relocating firms; firms locating near the periphery were mostly large ones. We also found distinct land use specialization patterns in Bogota. In the industrial corridor, which bisects the city into the residential north and the residential south and contains about three-fourths of manufacturing employment in Bogota, the percentage share of employment slightly decreased during the five-year period.

The annual growth rate of employment in mature firms was far lower than the overall growth rate in Bogota; the increase in the number of jobs in new firms (births) was about 60% more than the increase in mature firms. In Bogota, births and deaths of firms contributed significantly to changes in the spatial distribution of employment.

Ring 2, which is contiguous to the CBD, had the lowest growth of mature firms but a high birth rate. For this area, our data support the

modified case of the incubator hypothesis. By further spatial disaggregation, we identified the "incubation areas" as the analysis zones which are contiguous with the CBD in the industrial corridor, and the commerical corridor of the *Chapinero* area. The central industrial area's share of employment created by new firms was lower than its share of the base year employment.

About 80% of manufacturing employment in Bogota is concentrated in five non-durable and seven durable goods industries. The peak concentration of employment in the non-durable goods industries was in Ring 3, while durable goods industries were concentrated in Ring 4 as well as Ring 3. All of these industries, with the exception of the plastic and the electric machinery industries, showed a substantial degree of decentralization.

The estimates of "standard distances" revealed a general trend of increasing dispersion of manufacturing establishments over time. Nevertheless, by comparing the standard distances of firm births with those of mature firms, we found the degree of concentration increasing in the following industries: plastic, beverages, leather, paper, instruments, textile, electric machinery, and "other manufacturing." This may be due to the presence of agglomeration economies in their parent industries. The values of the contiguity index along with the standard distances indicate the single-centeredness of manufacturing employment in Bogota.

The findings in this paper provide evidence for a strong trend toward decentralization of Bogota's manufacturing employment. This trend is quite similar to what has occurred in large U.S. and European cities during the past several decades. Changes in production technology (requiring more space) and revolutions in transportation and communication were some of the major factors that produced employment decentralization in the U.S.; the same factors might well prevail in Bogota.

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THE WORLD BANK
Headquarters:
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