Employment subcenters in Chicago: Past, present, and future

Daniel P. McMillen

Introduction and summary

Employment in large American metropolitan areas has become increasingly decentralized over time. However, employment is not distributed evenly throughout the suburban landscape. Firms congregate at highway interchanges, along rail lines, and in former satellite cities. An employment *subcenter* is a concentration of firms large enough to have significant effects on the overall spatial distribution of population, employment, and land prices. Large subcenters can look remarkably similar to a traditional central business district (CBD), with thousands of workers employed in a wide variety of industries. A *polycentric* city—a metropolitan area with a strong central business district and large subcenters—can potentially combine the advantages of the traditional centralized city and a more decentralized spatial form. Large subcenters offer agglomeration economies to firms, while potentially reducing commuting times for suburban workers. As traffic congestion increases in the suburbs, an important advantage of subcenters over more scattered employment is they can potentially be served effectively with public transportation. As a result, the location and growth patterns of subcenters in major cities are of interest to policymakers.

In this article, I document the growth of employment subcenters in the Chicago metropolitan area from 1970 to 2000. I also use employment forecasts generated by the Northeastern Illinois Planning Commission to identify subcenters for 2020. Chicago had nine subcenters in 1970. The number of subcenters rose to 13 in 1980, 15 in 1990, and 32 in 2000, and is projected to drop to 24 in 2020. Existing subcenters are becoming larger and are particularly likely to expand along major expressways. I use a formal *cluster analysis* to categorize the subcenters by employment mix in 1980, 1990, and 2000. Although Chicago's subcenters had high concentrations of manufacturing jobs in the past, the industry mix now closely resembles that of the overall metropolitan area.

I use distance from the nearest subcenter as an explanatory variable in employment and population density regressions (density is the number of workers or residents per acre). The results imply that the traditional city center still has a significant and widespread influence on densities in the Chicago metropolitan area. Firms tend to locate near important parts of the transportation system—near highway interchanges and rail stations and along freight rail lines. Subcenters also have pronounced effects on the distribution of jobs: Employment density rises significantly near subcenters. However, apart from O'Hare Airport, Chicago's subcenters are still not large enough to increase population density in neighboring areas. Construction of high-density housing near subcenters could potentially reduce aggregate commuting costs.

Subcenters are not unique to the Chicago metropolitan area. In related work, McMillen and Smith (2004) have identified subcenters in 62 large American urban areas in 1990. All but 14 of these cities have employment centers. The Los Angeles and New York metropolitan areas have the most subcenters, with 46 in Los Angeles and 38 in New York. In all 62 of these urban areas, employment density continues to decline significantly with distance from the traditional city center. Employment density also declines significantly with distance from the nearest subcenter in those cities following a polycentric form. Using the subcenter count as the dependent variable for a Poisson regression, I find that the number of subcenters rises with the urban area's population, and cities with higher commuting costs tend to have more subcenters.

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Subcenters in the Chicago metro area

Subcenters are areas outside the traditional central business district with employment levels large enough to have significant effects on the overall spatial distribution of jobs and population. Subcenter locations are not always obvious or easy to identify beforehand. Areas near the city center with high employment density may not differ significantly from surrounding sites. Remote sites with relatively high employment densities may not have significant effects on the spatial distribution of jobs and population. Researchers such as McDonald (1987), Giuliano and Small (1991), Craig and Ng (2001), and McMillen (2001) have proposed procedures that objectively identify subcenter sites using standard data sources.

In this article, I use Giuliano and Small's (1991) approach to identify subcenters in the Chicago metropolitan area between 1970 and 2000 and to predict subcenter sites in 2020. Analyzing the Los Angeles metropolitan area, Giuliano and Small define a subcenter as a set of contiguous tracts that each have at least ten employees per acre and together have at least 10,000 employees.[1] The number of subcenters is sensitive to these two cutoffs. Higher minimum density levels or higher values for total employment produce fewer subcenters. To ensure reasonable results, one needs local knowledge to guide the choice of cutoffs. After some experimentation, I chose cutoff points of 15 employees per acre and 10,000 total workers. These values produce a reasonable number of subcenters in each period. McMillen and Smith (2004) provide a detailed explanation of the subcenter identification procedure.

Data on employment and population were provided by the Northeastern Illinois Planning Commission (NIPC). NIPC conducts decennial land use surveys for the six-county Chicago primary metropolitan statistical area. The six counties are Cook, DuPage, Kane, Lake, McHenry, and Will. The unit of observation is the quarter section, which is 160 acres or one-quarter of a square mile. There are slightly more than 15,000 quarter sections in these six counties. NIPC provided employment data for 1970, 1980, 1990, and 2000, and forecasts for 2020. Population data are not yet available for quarter sections in 2000, although forecasts are available for 2020. Comparisons over time for individual quarter sections are not completely reliable because NIPC has changed its methodology. In 1970 and 2020, NIPC reports employment data for any quarter section with jobs. In 1980 and 1990, only quarter sections with ten or more employees are included in the dataset, whereas the minimum employment level is eight in 2000. Due to this limitation, the dataset has more tracts with positive values for employment in 1970 than in 1980–2000, despite the general decentralization of the Chicago metropolitan area over this time.

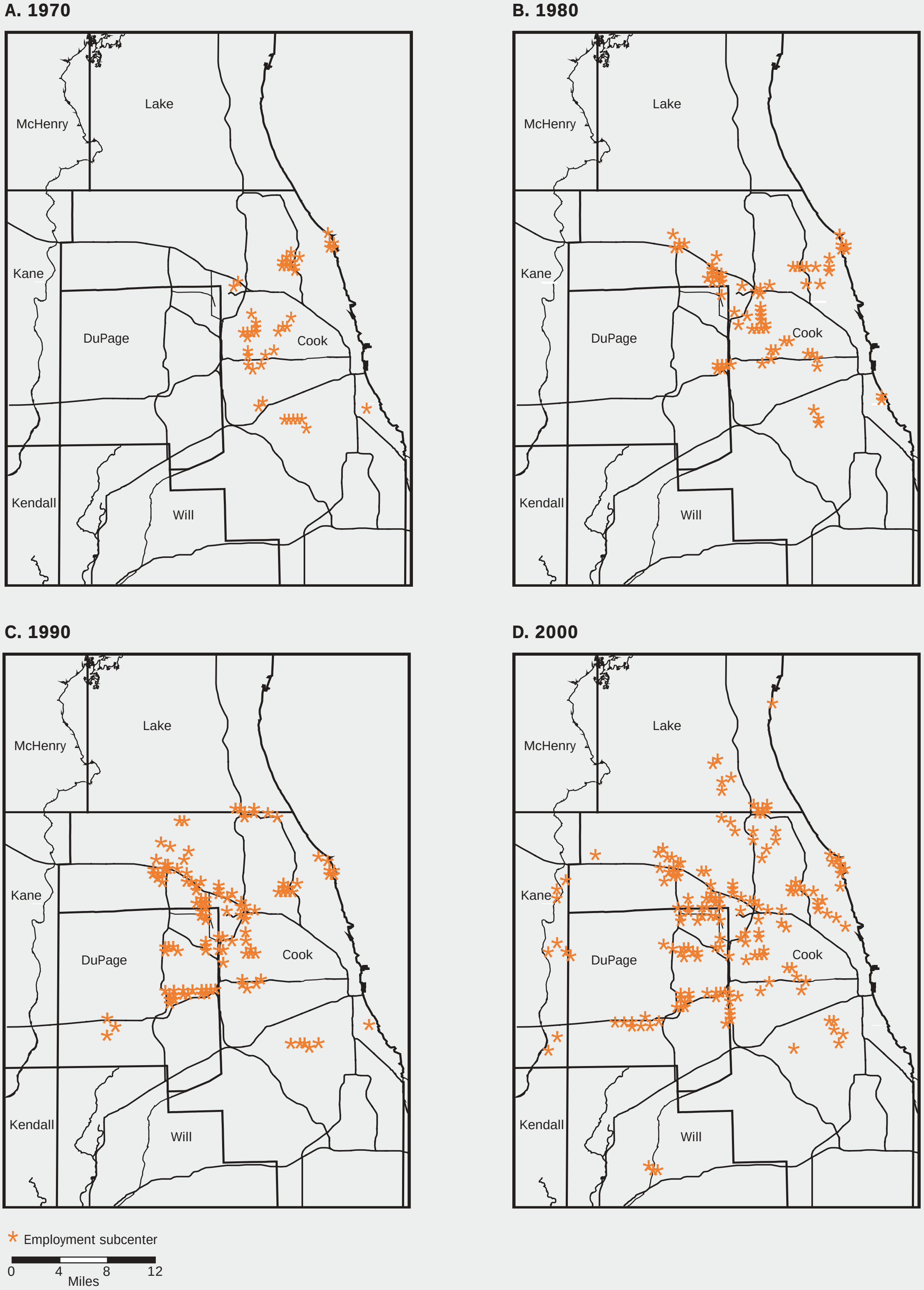
Figures 1 and 2 show the subcenter sites. The number of subcenters rises from nine in 1970 to 13 in 1980, 15 in 1990, and 32 in 2000. The NIPC employment forecasts lead to a prediction of 24 subcenters in 2020. Figure 1, panel A shows that in 1970 there was a subcenter in Hyde Park on the south side of Chicago, along with a ring of subcenters that nearly encircles the city. The number and geographic scope of the subcenters expand over time. O'Hare Airport is the center of a large conglomeration of subcenter employment. Another group of subcenters spreads along the I-88 toll way running west out of the city. In 2000 (panel D), small subcenters appear at the fringes of the metropolitan area in Kane County and Will County. These sites are in the old satellite cities of Elgin, St. Charles, Aurora, and Joliet. The NIPC forecasts suggest that the satellite cities will not continue to qualify for subcenter status in 2020, although the accuracy of this forecast appears questionable in light of the ongoing decentralization of employment in the Chicago metropolitan area. In 2020, also, several formerly separate subcenters along I-88 and near O'Hare are predicted to merge (figure 2). The general pattern of figure 1 is one of rapidly expanding subcenters, with most of the growth occurring near O'Hare Airport and along the major highways serving the city.

Subcenter clusters

Employment data are available by sector for 1980, 1990, and 2000. Table 1 presents data on the total number of jobs and the distribution of employment across five sectors in the subcenters identified for these years. The sectors are manufacturing; retail; services; transportation, communication, and utilities (TCU); finance, insurance, and real estate (FIRE); and government (federal, state, and local). I also use these sectors as headings for groups of similar subcenters that I identify using a formal cluster analysis. The cluster analysis[2] categorizes subcenters by looking for groups with similar employment compositions. The cluster analysis is performed for a given number of clusters, leaving it to the analyst to specify the appropriate number. Experimentation suggested that specifying five groups produces reasonable results, with clusters that are dominated by jobs in one of the five primary employment categories. Table 1 groups the subcenters by cluster in each year, with the subcenter sites identified by the municipalities (or neighborhoods within Chicago) in which they are located.

FIGURE 1

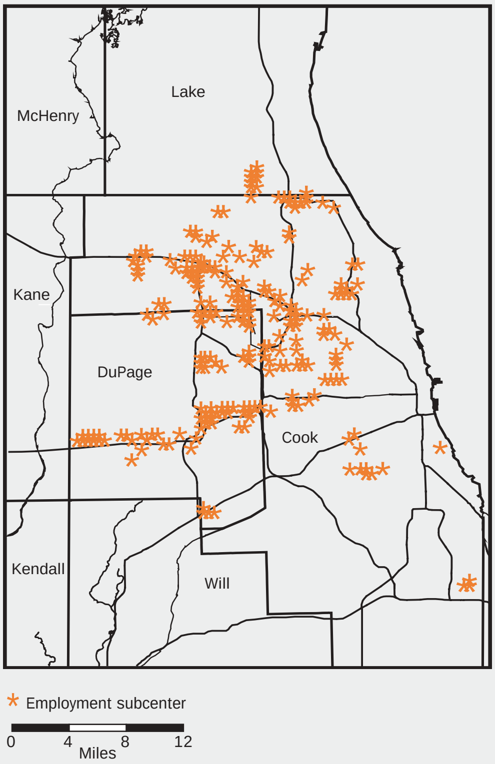
Subcenter locations



Source: Author's calculations based upon data from the Northeastern Illinois Planning Commission, 1970–2000, decennial land use surveys.

FIGURE 2

Subcenter locations in 2020



Source: Author's calculations based upon data from the Northeastern Illinois Planning Commission, 1970–2000, decennial land use surveys.

In 1980, eight of the 13 subcenters were dominated by manufacturing jobs. Traditional manufacturing sites such as Cicero, the Clearing District of Chicago, and Franklin Park appear as subcenters, along with newer suburban sites such as Elk Grove Village, Niles–Skokie, and Schaumburg. The manufacturing subcenters are generally larger than the service, TCU, and government subcenters, with total employment ranging from 13,430 in Rosemont to 46,740 in Franklin Park–Melrose Park. Although these subcenters are dominated by manufacturing, they also can include significant numbers of other types of jobs. For example, 28.89 percent of the Albany Park subcenter's jobs are in the FIRE sector, compared with 55.05 percent in manufacturing. The Clearing–West Lawn and Schaumburg subcenters have many retail jobs, representing 27.73 percent and 32.04 percent of the jobs in those subcenters, respectively. Rosemont is a diversified subcenter, having a similar number of jobs in manufacturing, service, TCU, and FIRE. Of the remaining subcenters in 1980, three specialize in the service sector (Evanston, Oak Brook, and the Hyde Park area of Chicago, which includes the University of Chicago), one specializes in TCU (O'Hare), and one specializes in government (Broadview–Maywood–Oak Park). Maywood has a significant county governmental facility, Broadview has several township offices, and Oak Park, which is fairly large in population, has several village and township offices. Oak Brook, which is the site of a regional shopping mall and is near the intersection of the Tri-State and East–West tollways, also includes many retail and TCU jobs: These two sectors account for 22.95 percent and 21.78 percent of the jobs in the subcenter, respectively.

Table 1 shows that the subcenters continue to be dominated by manufacturing jobs in 1990, although the locations have changed somewhat. Whereas the manufacturing subcenters were formerly concentrated in Chicago and in the near western suburbs, by 1990 they are more apt to be in the northwestern suburbs and near O'Hare Airport. New manufacturing sites in this area include Addison, Arlington Heights, and Palatine. Another new manufacturing subcenter appears in the rapidly growing western suburb of Naperville. These manufacturing subcenters range in size from 10,120 in Naperville to 95,420 in Elk Grove Village–Schaumburg. Several of the subcenters also include many TCU jobs, although they are placed in another category: TCU accounts for 38.51 percent of the jobs in the Addison subcenter, 20.21 percent in Bedford Park–Chicago Lawn–West Lawn, 22.97 percent in Des Plaines–Rosemont, 27.10 percent in Elk Grove Village–Schaumburg, 24.90 percent in Naperville, 21.65 percent in Niles–Skokie, and 40.82 percent in Palatine. Five subcenters specialize in service employment in 1990: The sector accounts for 48.78 percent of the employment in Bellwood–Broadview–Maywood, 32.47 percent in Deerfield–Northbrook, 57.74 percent in Evanston, 39.40 percent in Oak Brook, and 98.80 percent at the University of Chicago. The O'Hare subcenter continues to be dominated by TCU employment in 1990. None of the subcenters is placed in the government category in 1990.

The list grows to 32 subcenters in 2000 from 15 in 1990. The number of manufacturing subcenters falls to six—Addison, Glenview, North Chicago, Schaumburg, St. Charles, and Wheeling. All the manufacturing subcenters are now in more distant suburbs. Retail appears as a subcenter category in 2000, with sites in Deerfield–Northbrook (classified as service in 1990), Franklin Park, Hoffman Estates, and Melrose Park. The Hoffman Estates subcenter is a result of the movement of the Sears corporate headquarters out of Chicago. The number of service sector subcenters also increases significantly, with sites in Aurora, Broadview–Forest Park, Cicero–Oak Park, Elk Grove Village,

TABLE 1

Subcenter characteristics

Subcenter	Cluster	Total employment	Mfg.	Retail	Services	TCU	FIRE	Government
			Subcenter employment composition (%)					
			1980					
Albany Park–Jefferson Park–North Park	mfg	14,640	55.05	0.41	2.53	3.48	28.89	6.63
Cicero–Austin	mfg	28,210	62.96	17.23	4.86	8.29	0.00	2.30
Clearing–West Lawn	mfg	10,890	45.36	27.73	1.65	10.65	3.86	10.74
Elk Grove Village	mfg	37,030	39.08	7.05	3.83	44.56	0.16	0.00
Franklin Park–Melrose Park	mfg	46,740	68.66	11.49	2.55	9.52	0.06	5.88
Niles–Skokie	mfg	40,800	65.66	5.96	5.27	17.28	1.81	0.20
Rosemont	mfg	13,430	18.63	8.59	24.11	25.89	17.96	1.55
Schaumburg	mfg	23,000	46.22	32.04	4.13	6.61	6.00	4.91
Evanston	serv	22,430	3.79	12.26	51.67	2.41	25.28	4.15
Oak Brook	serv	27,500	12.36	22.95	30.25	21.78	10.40	0.55
University of Chicago (Hyde Park)	serv	15,300	0.07	0.26	96.08	0.33	0.07	2.75
O'Hare	tcu	11,970	0.00	20.55	10.69	51.04	0.00	17.71
Broadview–Maywood–Oak Park	govt	22,260	7.23	10.42	36.21	12.62	5.75	27.18
			1990					
Addison	mfg	11,790	42.32	0.85	7.46	38.51	0.34	1.10
Arlington Heights	mfg	15,270	55.73	4.98	7.60	7.99	4.58	0.00
Bedford Park–Chicago Lawn–West Lawn	mfg	16,230	49.23	5.67	12.14	20.21	0.25	12.26
Des Plaines–Rosemont	mfg	44,070	24.95	8.46	25.86	22.97	10.29	3.53
Elk Grove Village–Schaumburg	mfg	95,420	33.03	11.04	15.05	27.10	7.68	1.07
Elmhurst–Franklin Park–Melrose Park–Northlake	mfg	50,250	46.61	14.31	13.47	14.83	1.59	6.79
Naperville	mfg	10,120	17.00	13.54	22.73	24.90	2.87	12.45
Niles–Skokie	mfg	27,620	45.08	5.25	14.45	21.65	5.54	0.91
Palatine	mfg	10,290	49.17	2.82	4.76	40.82	2.04	0.00
Bellwood–Broadview–Maywood	serv	21,730	17.67	1.47	48.78	12.43	0.18	17.35
Deerfield–Northbrook	serv	26,730	17.92	22.15	32.47	16.46	7.00	0.19
Evanston	serv	25,580	7.00	12.51	57.74	2.15	13.88	3.91
Oak Brook	serv	76,760	7.43	18.88	39.40	20.64	8.91	0.81
University of Chicago (Hyde Park)	serv	16,670	0.00	0.54	98.80	0.12	0.00	0.00
O'Hare	tcu	40,340	0.00	9.22	7.68	76.03	0.05	6.79
			2000					
Addison	mfg	29,593	33.12	8.01	10.57	38.03	0.56	0.00
Glenview	mfg	15,215	40.47	5.49	24.96	23.35	0.20	0.00
North Chicago	mfg	19,432	88.30	0.00	0.00	11.70	0.00	0.00
Schaumburg	mfg	82,092	40.01	13.11	19.39	6.80	3.55	0.00
St. Charles	mfg	10,815	51.20	16.98	16.38	6.03	2.64	4.28
Wheeling	mfg	10,595	24.68	1.52	25.16	16.64	0.28	0.00
Deerfield–Northbrook	retl	51,253	4.06	49.45	23.79	14.07	3.80	1.50
Franklin Park	retl	25,064	30.93	47.12	2.29	16.66	0.00	0.37
Hoffman Estates	retl	17,355	0.00	100.00	0.00	0.00	0.00	0.00
Melrose Park	retl	54,550	6.19	71.37	16.18	4.41	0.92	0.00
Aurora–South	serv	10,570	0.52	1.96	50.23	1.42	13.52	19.01
Broadview–Forest Park	serv	28,119	8.70	0.79	88.33	1.64	0.00	0.00
Cicero–Oak Park	serv	15,609	3.57	5.45	63.58	3.13	8.50	2.94
Elk Grove Village	serv	101,012	20.92	4.19	36.98	22.73	9.88	1.11
Evanston	serv	46,957	1.08	5.40	72.00	0.37	1.09	14.01
Glenbard	serv	28,242	3.83	16.07	57.40	13.26	8.31	0.00
Joliet	serv	10,917	0.35	5.06	43.67	2.83	4.09	21.89
Lincolnshire	serv	33,121	5.64	3.34	78.27	11.85	0.00	0.00
Lisle–Naperville	serv	34,197	8.76	14.42	40.79	17.02	16.16	0.66
Oak Brook	serv	78,810	3.56	19.17	49.74	12.15	13.24	0.05
Bedford Park	tcu	18,790	4.28	0.00	1.37	94.10	0.00	0.00
Bensenville–Elmhurst	tcu	29,253	17.71	9.65	28.82	37.45	2.22	0.00
Midway Airport	tcu	20,183	12.35	15.40	14.16	35.18	22.22	0.00
O'Hare	tcu	61,527	0.00	9.57	3.02	87.37	0.00	0.00
Vernon Hills	tcu	13,599	11.42	9.25	8.93	45.97	24.42	0.00
Prospect Heights	fire	20,913	4.19	6.16	1.32	2.55	85.77	0.00
Arlington Heights	govt	14,270	5.88	1.97	23.75	5.05	1.85	30.07
Aurora–North	govt	14,268	0.00	0.00	0.00	0.00	0.00	99.41
Des Plaines–Rosemont	govt	67,565	19.27	2.82	28.33	16.19	4.72	27.69
Elgin	govt	26,119	11.58	0.89	12.68	0.50	0.00	61.50
Niles–Skokie–Northern Chicago	govt	59,806	30.68	4.03	23.16	8.18	1.83	27.63
Norridge–Norwood Park	govt	16,662	16.20	1.75	31.53	2.04	0.18	46.61

Notes: Mfg. is manufacturing; TCU is transportation, communications, and utilities; and FIRE is finance, insurance, and real estate.
Source: Northeastern Illinois Planning Commission, 1970–2000, decennial land use surveys.

Evanston, Glenbard, Joliet, Lincolnshire, Lisle–Naperville, and Oak Brook. In addition, TCU accounts for five subcenters in 2000, one subcenter specializes in FIRE, and six have large concentrations of government employment. The largest subcenters are in Schaumburg (82,092 employees) and Elk Grove Village (101,012 employees). In 2000, the subcenter job mix closely resembles the employment composition of the full metropolitan area.[3]

Employment and population density in Chicago

The spatial distribution of jobs and residences can be summarized by regressing measures of employment and population density on a set of explanatory variables, including distance from Chicago's traditional city center and measures of proximity to subcenter sites. Population density functions have a long history in urban economics, dating back to Clark (1951). Issues involved in estimation and a review of studies up to the late 1980s are reviewed in McDonald (1989). Employment density functions are estimated less frequently. Prominent examples include Booth (1999), Combes (2000), McDonald (1985), McDonald and Prather (1994), McMillen and McDonald (1997), and Small and Song (1994). With the natural logarithm of density as the dependent variable, the coefficient for distance from the central business district (CBD) or city center is referred to as the "CBD gradient." The gradient measures the percentage change in density associated with a one-mile increase in distance from the city center. It is a simple measure of centralization: Density declines rapidly with distance in a highly centralized city, leading to large negative values for the estimated CBD gradient. Empirical studies suggest that most cities in the world have become increasingly decentralized over the last century, although employment generally remains more centralized than population.

Explanatory variables for the estimated density functions include distance from the traditional city center at the intersection of State and Madison streets, distance from O'Hare Airport, and distance from the nearest quarter section that is part of a subcenter. Distance from the nearest subcenter enters the estimating equations in inverse form, because I expect the effect of proximity to a subcenter to decline rapidly with distance. Proximity to subcenters increases densities if the coefficient for this variable is positive, and the effect rises over time if the coefficient becomes larger over time.

Other explanatory variables have localized effects on densities that can be accounted for using simple dummy variables. I include dummy variables that equal one when a quarter section is within one-third of a mile and between one-third and one mile of the following sites: a highway interchange, a commuter rail station, an elevated train line (the "el"), a station on an electric line serving the South Side, and Lake Michigan. I distinguish between commuter rail, el, and electric train lines because they have different areas and clienteles. The commuter rail lines primarily serve the suburbs, and have long intervals between stops. El lines are nearly entirely within the City of Chicago, and have frequent stops. The electric train line is something of a hybrid. It runs from downtown Chicago to the distant southern suburbs, along with a separate spur to Northwest Indiana. Although it primarily serves suburbanites, it resembles the el in making frequent stops within the city.

Table 2 presents detailed employment density estimates. The results indicate that employment fell by 5.6 percent with each mile from the Chicago city center in 1970. The rate of decline falls to 2.2 percent in 1980 as Chicago becomes more decentralized, and remains at about that level for 1990 (2.3 percent) and 2000 (2.2 percent again). The rate of decline is expected to be 1.9 percent per mile in 2020, based on NIPC employment forecasts. With the exception of 2000, proximity to O'Hare also increases employment density. Employment density is estimated to decline by 1.0 percent per mile in 1980, 0.9 percent in 1990, and a forecasted 3.4 percent in 2020.

Other results in table 2 are much as expected. Employment density is higher near highway interchanges. Densities are estimated to be 30.6 percent higher within one-third of a mile of a highway interchange in 1970, compared with 37.9 percent in 2000, and a forecasted 40.5 percent in 2020. Densities decline somewhat in the next two-thirds of a mile from a highway interchange. In 1970, densities are 18.1 percent higher in the ring from one-third to one mile of a highway interchange than in more distant sites, compared with 21.6 percent in 2000 and a forecasted 13.6 percent in 2020. Similarly, densities are higher near commuter rail stations. For example, in 1970 employment density is estimated to be 85.2 percent higher within one-third of a mile of a commuter station and 50.6 percent higher in the one-third to one-mile ring, compared with more distant locations. Commuter train stations decline in importance in subsequent years. In 2020, employment density is expected to be 54.5 percent higher within one-third of a mile of a commuter station and 9.4 percent higher in the one-third to one-mile ring. Proximity to stations on the electric line has similar effects on employment, except the effect is confined to the initial zero to one-third of a mile ring.

TABLE 2

Total employment density

	1970	1980	1990	2000	2020
Miles from city center	–0.056	–0.022*	–0.023*	–0.022*	–0.019*
	(15.742)*	(7.685)	(9.311)	(6.334)	(7.448)
Miles from O'Hare Airport	–0.005	–0.010*	–0.009*	0.005	–0.034*
	(1.599)	(3.521)	(3.461)	(1.423)	13.523)
0 – 1/3 mile from highway interchange	0.306*	0.266*	0.287*	0.379*	0.405*
	(3.132)	(3.759)	(4.478)	(5.048)	(5.678)
1/3 – 1 mile from highway interchange	0.181*	0.259*	0.180*	0.216*	0.136*
	(2.996)	(5.682)	(4.309)	(4.514)	(2.974)
0 – 1/3 mile from commuter rail station	0.852*	0.541*	0.576*	0.608*	0.545*
	(5.858)	(5.102)	(5.632)	(5.141)	(4.619)
1/3 – 1 mile from commuter rail station	0.506*	0.182*	0.106*	0.127*	0.094**
	(8.123)	(3.839)	(2.414)	(2.520)	(1.891)
0 – 1/3 mile from el station	0.937*	0.770*	1.038*	0.551*	1.152*
	(5.752)	(6.401)	(9.147)	(4.232)	(8.634)
1/3 – 1 mile from el station	0.557*	0.291*	0.592*	0.146	0.500*
	(4.877)	(3.400)	(7.339)	(1.558)	(5.349)
0 – 1/3 mile from station on electric line	0.805*	0.553*	0.572*	0.564*	0.770*
	(2.887)	(2.711)	(2.952)	(2.560)	(3.431)
1/3 – 1 mile from station on electric line	0.173	0.173**	–0.036	0.027	0.329*
	(1.244)	(1.671)	(0.376)	(0.233)	(3.012)
0 – 1/3 mile from Lake Michigan	–0.207	0.015	–0.228	0.197	0.173
	(1.054)	(0.090)	(1.478)	(1.065)	(0.991)
1/3 – 1 mile from Lake Michigan	0.276*	0.223*	0.005	0.100	0.267*
	(2.019)	(2.084)	(0.049)	(0.863)	(2.307)
Chicago River or canal runs through tract	0.386	0.433*	0.284**	0.583*	–0.020
	(1.552)	(2.532)	(1.719)	(2.906)	(0.108)
Freight rail line within tract	0.723*	0.398*	0.356*	0.250*	0.430*
	(12.893)	(9.305)	(9.122)	(5.546)	(10.105)
Within City of Chicago	1.035*	0.396*	0.135*	–0.044	0.065
	(11.917)	(5.909)	(2.174)	(0.601)	(0.936)
Inverse of distance from the nearest subcenter	0.774*				0.568*
	(19.209)				(27.253)
Nearest subcenter is in retail cluster				0.044	
				(0.448)	
Nearest subcenter is in government cluster		0.164		0.208*	
		(1.123)		(2.195)	
Nearest subcenter is in service cluster		–0.037	0.047	–0.209*	
		(0.823)	(1.001)	(2.746)	
Nearest subcenter is in TCU cluster		0.431	–4.978*	–0.141	
		(1.200)	(1.965)	(1.642)	
Nearest subcenter is in FIRE cluster				–1.218*	
				(2.390)	
Inverse of distance from nearest subcenter × retail cluster				0.758*	
				(13.840)	
Inverse of distance from nearest subcenter × government cluster		0.471*		0.645*	
		(5.161)		(13.685)	
Inverse of distance from nearest subcenter × service cluster		0.564*	0.600*	0.784*	
		(11.493)	(19.102)	(24.082)	
Inverse of distance from nearest subcenter × TCU cluster		0.754*	2.510*	0.756*	
		(4.016)	(3.707)	(11.237)	
Inverse of distance from nearest subcenter × manufacturing cluster		0.665*	0.670*	0.768*	
		(23.708)	(28.658)	(17.003)	
Inverse of distance from nearest subcenter × FIRE cluster			0.992*		
				(3.707)	
Constant	–0.325*	0.253*	0.403*	0.078*	0.840*
	(3.553)	(3.345)	(5.677)	(0.799)	(11.308)
R^2	0.425	0.364	0.390	0.314	0.376
Number of observations	6,081	5,220	5,817	5,649	7,522

Notes: Absolute *t*–values are in parentheses. The dependent variable is the natural logarithm of employment density per acre.
"*" indicates significance at the 5 percent level; and "**" indicates significance at the 10 percent level.
Source: Author's calculations based on data from the Northeastern Illinois Planning Commission, 1970–2000, decennial land use surveys.

Lake Michigan has little or no effect on employment density. Quarter sections through which the Chicago River or the Sanitary and Ship Canal runs tend to have high employment density. In 2000, densities are estimated to be 58.3 percent higher in quarter sections with the river or canal. Although sites within Chicago had higher densities from 1970 to 1990, the effect declines from a 103.5 percent increase in 1970 to 39.6 percent in 1980 to 13.5 in 1990. After controlling for other explanatory variables, city locations do not have higher employment density in 2000 or 2020.

The final set of results in table 2 includes the effects of proximity to subcenters on employment density. The 1970 and 2020 regressions include a single variable representing the inverse of distance from the nearest subcenter. The regressions confirm the importance of subcenters in accounting for the spatial distribution of employment density. Letting d represent the distance from the nearest subcenter, the marginal effect of distance is $-0.774/d^2$ in 1970 and a forecasted $-0.568/d^2$ in 2020. The minimum value for d is 0.25. Thus, the estimated marginal effect of distance from the nearest subcenter in 1970 is –12.38 at subcenter sites, with the effect falling to –0.77 after one mile, and –0.19 after two miles. Comparable values for 2020 are –9.09, –0.57, and –0.142, respectively. Although subcenters do not affect employment over as wide an area as the traditional CBD, the high t-values of 19.209 in 1970 and 27.253 in 2020 indicate that they are critically important determinants of the spatial distribution of jobs in the Chicago area.

For the years with data on employment sectors (1980, 1990, and 2000), I include separate explanatory variables for each cluster type. For these years, the regressions include dummy variables indicating the sector for the closest subcenter and interactions between these dummy variables and the inverse of distance from the subcenter. The dummy variables are generally not statistically significant. The coefficients for the inverse of distance from the nearest subcenter again indicate that employment densities rise significantly near subcenters. In 1980, the marginal effect of distance from the nearest subcenter is –0.471 at a distance of one mile when the nearest subcenter is in the government cluster, compared with –0.564 for service subcenters, –0.754 for TCU, and –0.665 for manufacturing. In 1980, these marginal effects are –0.600 for service, –2.510 for TCU, and –0.670 for manufacturing. In 2000, the marginal effect at one mile from a subcenter is –0.758 for retail, –0.645 for government, –0.784 for service, –0.756 for TCU, and –0.768 for manufacturing. The results are all highly significant. What is more surprising is that, with the exception of the TCU cluster in 1990, the estimated marginal effects do not vary much across sectors.

Table 3 presents abbreviated results for comparable population density function estimates. Population density is estimated to decline by 7.3 percent with each mile from the Chicago city center in 1970, compared with 7.8 percent in 1980, 7.2 percent in 1990, and a forecasted 6.6 percent in 2020 (recall that population data are not yet available for 2000 at the quarter section level). These results are somewhat surprising in their implication that the CBD gradient is now larger for population than for jobs after controlling for the effects of other variables. O'Hare Airport also has a significant effect on population density. Controlling for other variables, each additional mile from O'Hare reduces population density by 4.9 percent in 1970, 4.6 percent in 1980, 6.0 percent in 1990, and a forecasted 5.9 percent in 2020.

In keeping with the results of McMillen and McDonald (2000), proximity to employment subcenters is estimated to *reduce* population density. Each additional mile from the nearest employment subcenter increases density by 16.4 percent in 1970, 44.9 percent in 1980, 36.2 percent in 1990, and a forecasted 47.3 percent in 2002. This result has two explanations. First, our density measures are gross rather than net, meaning that density is measured per acre of total land area rather than per acre of residential land area. Densities are low near subcenters because by definition much of the land area in subcenters is in nonresidential use.

TABLE 3

Population density

	1970	1980	1990	2020
Miles from city center	–0.073 (30.963)	–0.078 (31.107)	–0.072 (29.670)	–0.066 (28.345)
Miles from O'Hare Airport	–0.049 (22.795)	–0.046 (20.052)	–0.060 (25.880)	–0.059 (25.942)
Inverse of distance from nearest subcenter	–0.164 (4.305)	–0.449 (13.263)	–0.362 (12.589)	–0.473 (18.731)
R^2	0.512	0.423	0.429	0.361
Number of observations	10369	10942	11129	11687

Notes: Absolute t–values are in parentheses. The dependent variable is the natural logarithm of population density. Other explanatory variables include dummy variables representing locations within the City of Chicago and proximity to highways, commuter rail lines, el lines, electric train lines, Lake Michigan, the Chicago River and the Sanitary and Ship Canal, and freight rail lines.

Source: Author's calculations based on data from the Northeastern Illinois Planning Commission, 1970–2000, decennial land use surveys.

Second, although subcenters are getting bigger, they are not yet large enough in the Chicago area to lead to large increases in population density in neighboring sites. Subcenter employment has increased primarily through an increase in the number of subcenters rather than by the creation of a few larger subcenters that rival the traditional CBD in their effects on density patterns.

Subcenters in other metro areas

Subcenters are not only a Chicago phenomenon. Studies by Anderson and Bogart (2001), Bogart and Ferry (1999), Cervero and Wu (1997, 1998), Craig and Ng (2001), Giuliano and Small (1991), McMillen (2001), and Small and Song (1994) have identified subcenters in Cleveland, Dallas, Houston, Indianapolis, Los Angeles, New Orleans, St. Louis, and the San Francisco Bay Area. Recently, Baumont, Ertur, and LeGallo (2002) and Muñiz, Galindo, and García (2003) have extended the analysis to the European cities of Dijon, France and Barcelona, Spain.

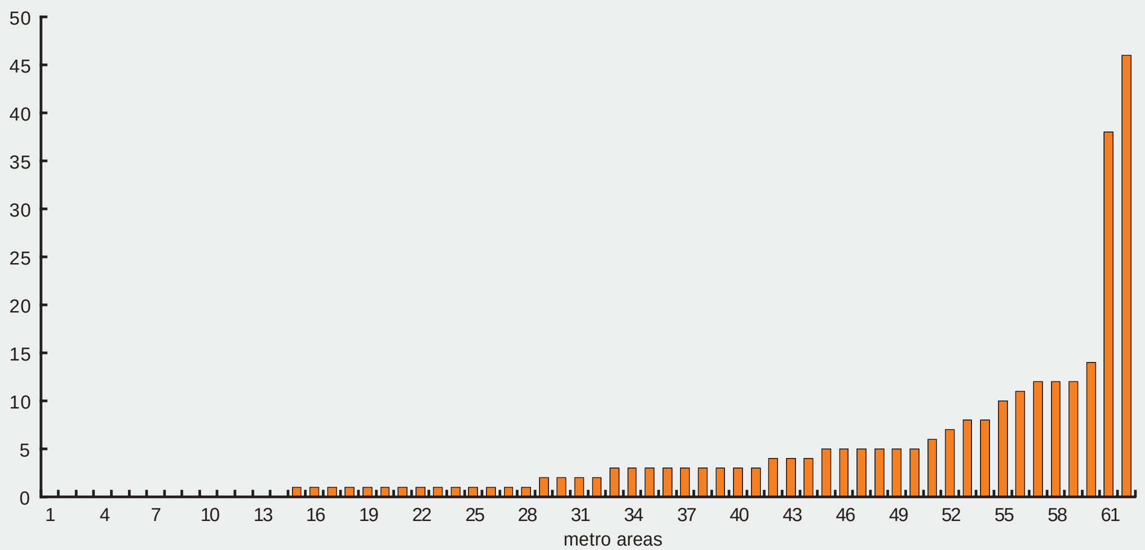
The remainder of this section summarizes the results of a recent study by McMillen and Smith (2004), which is the first to apply a single subcenter identification procedure to a large number of metropolitan areas. They use a variant of the Giuliano and Small (1991) procedure to identify subcenters in 62 large U.S. metropolitan areas. The data come from the urban element of the Census Transportation Planning Package, which is produced by the Department of Transportation's Bureau of Transportation Statistics (BTS). The BTS obtained special tabulations of 1990 U.S. Census data to match Census data with the BTS geographic unit, called the Transportation Analysis Zone. These zones, which vary across metropolitan areas, are typically smaller than Census tracts or zip codes and often are the same as Census blocks.

Figure 3 shows the distribution of the number of subcenters across the 62 metropolitan areas. Fourteen of the metropolitan areas have no subcenters. Eight metropolitan areas—Boston, Chicago, Dallas–Fort Worth, Los Angeles, New York, the San Francisco Bay Area, Seattle, and Washington, DC—have at least ten subcenters. The two largest cities, New York and Los Angeles, have the most subcenters with 38 and 46, respectively. Chicago is next with 15.

For a subset of the 62 metropolitan areas, table 4 presents the results of simple regressions of the natural logarithm of employment density on distance from the traditional central business district and the inverse of distance from the nearest zone that is part of a subcenter. The R^2s for the regression indicate that these two variables alone account for no less than 21.7 percent of the variation in employment density (in San Francisco), with an average of 38.3 percent and a maximum of 57.0 percent (in Washington, DC). The traditional CBD still has a tremendous impact on employment

FIGURE 3

Number of subcenters by metro area



Source: Author's calculations based upon data from the Northeastern Illinois Planning Commission, 1970–2000, decennial land use surveys.

TABLE 4

Employment density functions for selected metro areas, 1990

Metro area	No. of subcenters	CBD coefficient	*t*–value	Subcenter coefficient	*t*–value	R^2	*n*
Atlanta	4	–0.213	–34.307	0.482	9.266	0.569	943
Boston	11	–0.097	–31.519	0.353	19.013	0.267	3744
Chicago	15	–0.042	–28.760	0.649	36.607	0.340	5935
Cincinnati	3	–0.170	–20.370	0.297	3.656	0.313	958
Cleveland	3	–0.138	–24.385	0.199	3.153	0.399	991
Dallas	12	–0.089	–34.565	0.532	26.049	0.297	4379
Denver	5	–0.095	–19.545	0.419	8.864	0.277	1336
Detroit	8	–0.106	–35.274	0.484	19.342	0.388	2688
Houston	8	–0.118	–33.938	0.583	14.747	0.399	2128
Kansas City	2	–0.227	–26.767	0.487	5.896	0.529	732
Los Angeles	46	–0.048	–16.779	0.449	20.846	0.201	3051
Minneapolis–St. Paul	7	–0.201	–34.608	0.373	11.020	0.559	1187
New York	38	–0.097	–77.606	0.172	17.631	0.306	14831
Philadelphia	4	–0.109	–25.083	0.527	9.072	0.363	1350
Phoenix	5	–0.206	–31.049	0.308	7.923	0.545	996
San Diego	6	–0.090	–15.121	0.335	6.369	0.299	632
San Francisco	12	–0.056	–24.195	0.378	16.080	0.217	2913
Seattle	14	–0.133	–21.009	0.438	11.255	0.404	828
St. Louis	5	–0.165	–24.630	0.453	7.378	0.420	995
Washington, DC	10	–0.153	–55.863	0.416	22.782	0.570	3090

Note: The explanatory variables include an intercept, distance from the city center, and the inverse of distance from the nearest subcenter.
Source: Author's calculations based upon data from the U.S. Department of Transportation, Bureau of Transportation Statistics, *Census Transportation Planning Package*.

densities. For example, employment densities in Atlanta are estimated to decline by 21.3 percent with each additional mile from the CBD after controlling for proximity to subcenters. In table 4, the average CBD gradient is –12.8 percent, with a range of –4.2 percent in Chicago to –22.7 percent in Kansas City.

The coefficients for the inverse of distance from the nearest subcenter zone indicate that employment densities are higher near subcenters. For example, in Atlanta the estimated marginal effect of distance from the nearest subcenter is estimated to be $-0.482/d^2$, where d is distance. The marginal effect of distance is –7.71, –.48, and –.12 for sites that are one-quarter mile, one mile, and two miles, respectively, from the nearest subcenter in Atlanta. The average coefficient for distance from the nearest subcenter is 0.417 in table 4, with a range of 0.172 (New York) to 0.649 (Chicago). These results imply that the rate of decline in employment densities with distance from the nearest subcenter is highest in Chicago and lowest in New York.

Theoretical and empirical models of subcenter formation have thus far developed in relative isolation. Theoretical models have focused on examining the equilibrium spatial configuration of polycentric cities rather than on producing empirically testable, comparative static results. Models such as those developed by Anas and Kim (1996), Berliant and Konishi (2000), Fujita, Krugman, and Mori (1999), Fujita and Ogawa (1982), Fujita, Thisse, and Zenou (1997), Helsley and Sullivan (1991), Henderson and Mitra (1996), Konishi (2000), Wieand (1987), and Yinger (1992) emphasize the role that population and commuting cost play in altering the equilibrium spatial configuration of a city. The primary prediction is that the equilibrium number of subcenters tends to rise with population and commuting costs.

This prediction can be tested for our sample of 62 metropolitan areas using the number of subcenters as the dependent variable. Poisson regression is the appropriate estimation procedure for this type of count data (Cameron and Trivedi, 2001). The key explanatory variables are population and commuting costs. Population, which is measured over the full metropolitan area, ranges from 127,855 in Laredo, Texas, to 16,885,598 in New York. I use two measures of commuting cost. The first is a travel time index developed by the Texas Transportation Institute for its Mobility Monitoring Program. It is designed as a measure of peak-period congestion. The Travel Rate Index exceeds 1.0 if it takes longer on average to make a trip in congested periods than at other times of the day. As an alternative, I also use a measure of highway capacity—thousands of miles traveled on average daily by all vehicles per mile of freeway lanes (*DVMTLANE*). This index focuses on average travel time across the day, whereas the travel time index focuses on travel at peak commuting times. Its advantage is that it has a greater claim to being exogenous or predetermined: The highway capacity in most American cities is a direct result of federal highway programs from the 1950s and 1960s. Strict exogeneity is not essential because I am estimating an equilibrium relationship. The correlation is high among all of the indexes available from the Texas Transportation Institute's Urban Mobility Study, and the results are not sensitive to the choice.

Other explanatory variables control for differences among cities. I include the central city's proportion of the urban area's population, because subcenters may be more likely to form when there are more suburbs. Competition among suburbs for firms may produce subcenters, whereas a large central city may adopt policies to encourage the continued dominance of the traditional CBD. The median income of the central city has ambiguous effects on subcenter formation. On the one hand, high income suggests a vibrant central city, which may discourage subcenter formation. But incomes in the central city and suburbs are highly correlated, and subcenters may be more likely to form if higher income increases the aversion to long commutes.

TABLE 5

Poisson regressions: Number of subcenters

	Number of subcenters		
	Model 1	Model 2	Model 3
Metro population (millions)	0.148* (7.015)	0.151* (7.670)	0.173* (12.846)
Travel Rate Index	1.223* (2.878)		
DVMTLANE		0.094 (3.190)	0.093 (5.441)
Proportion of metro population in central city	–1.479* (2.494)	–1.490* (2.522)	–1.710* (3.694)
Median income in central city ($1,000)	0.029 (1.512)	0.027 (1.409)	
Average tract size (sq. miles)	–0.053 (1.293)	–0.046 (1.125)	
Median house age (10 yrs.)	0.058 (0.403)	0.026 (0.175)	
Central city age (10 yrs.)	–0.006 (0.135)	0.012 (0.256)	
Constant	–1.045 (1.390)	–0.627 (0.900)	0.124 (0.419)
Log-likelihood value	–119.217	–118.177	–120.395
R^2	0.811	0.816	0.806

Notes: Each regression has 62 observations. Absolute *z*-values are in parentheses below the estimated coefficients. An asterisk indicates significance at the 5 percent level.

Source: Author's calculations based upon data from the U.S. Department of Transportation, Bureau of Transportation Statistics, *Census Transportation Planning Package*, and from the U.S. Department of Commerce, Bureau of the Census.

I include the average tract size in the regressions, because McMillen and Smith (2004) find that the subcenter identification procedure tends to find more subcenters when tract sizes are small. I include the last two variables, median house age and the age of the central city, because analysts such as Garreau (1991) have suggested that subcenters will come to dominate American cities in the future. Thus, newer cities may be more likely to have already developed subcenters. Median house age, as reported by the 1990 U.S. Census for 1990, is one measure of a city's age. I also use a variable suggested by Brueckner (1986) to measure city age: the number of years since the central city first reached 25 percent of its 1990 population level.

Table 5 displays the Poisson regression results. The estimated coefficients are interpreted as semi-elasticities. For example, the estimated coefficient for population in model 1 indicates that an additional million in population raises the expected number of subcenters by 14.8 percent. This estimate is stable across the three alternative model specifications, rising to 15.1 percent when I use *DVMTLANE* in place of the travel rate index to measure commuting cost and to 17.3 percent when I use only population and *DVMTLANE* as explanatory variables. The travel rate index and *DVMTLANE* have the expected positive signs, indicating that higher commuting cost leads to more subcenters. The coefficients for *DVMTLANE* indicate that an additional thousand miles traveled on average per mile of freeway lane raises the expected number of subcenters by 9.4 percent in model 2 and 9.3 percent in model 3.

The remaining explanatory variables are not important determinants of the number of subcenters in this sample. Metropolitan areas with large central cities tend to have fewer subcenters, but estimated coefficients for other explanatory variables—median income, average tract size, median house age, and age of the central city—are statistically insignificant. The pseudo-R^2s for the regressions (Cameron and Windmeijer, 1996) imply that the explanatory variables account for approximately 80 percent of the variation in the natural logarithm of the number of subcenters. Table 5 suggests a strong, simple empirical regularity in the number of subcenters in large metropolitan areas: The number of subcenters rises with population and commuting costs.

Conclusion

The traditional central business district is still the largest single employment site in most metropolitan areas. However, urban areas have become increasingly decentralized over time, and many cities now have more jobs in the suburbs than in the central city. Jobs are not spread randomly about the suburban landscape. Firms tend to locate at sites with ready access to the transportation system. Large employment subcenters have developed in many metropolitan areas that offer agglomeration economies to firms, while potentially reducing commuting times for suburban workers.

This article has documented the growth of employment subcenters in the Chicago metropolitan area between 1970 and 2000 and used forecasts of future employment to predict subcenter sites in 2020. A cluster analysis suggests that the employment mix in the subcenters has changed from predominantly manufacturing in 1970 to a mix that now closely resembles that of the overall metropolitan area. A regression analysis of employment density in the Chicago metropolitan area suggests that density rises near highway interchanges, rail stations, and along freight rail lines. Employment density also rises significantly in the area around employment subcenters.

Subcenters are found throughout the United States. Chicago had only 15 subcenters in 1990, New York had 38, and Los Angeles had 46. Of 62 large metropolitan areas analyzed in this article, 48 had at least one subcenter. The number of subcenters has a remarkably predictable pattern across the 62 urban areas. Poisson regression results imply that the number of subcenters rises with population and commuting costs. Thus, as cities grow, one can expect that subcenters will develop as firms congregate near intersections of major highways and in formerly satellite cities. Although new subcenters do not offer the same level of agglomeration economies as the traditional central city, they do offer lower land costs, easy access to highways, and the possibility of reduced wages for suburban workers whose commuting costs are reduced.

NOTES

[1]The tracts analyzed by Giuliano and Small (1991) are transportation analysis zones, as defined by the Southern California Association of Governments. The average area of the tracts is about 1.75 square miles.

[2]Performed using the program STATA.

[3]In 2000, 33.7 percent of the jobs in the Chicago metropolitan area were in the service sector, 19.3 percent were in retail, 11.3 percent were in manufacturing, 11.1 percent were in TCU, and 4.3 percent were in the government sector.

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