

Identifying Multiple Nuclei of Metropolitan Areas Using an Employment Approach

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Abstract

Demographers, sociologists, and geographers have long studied the spatial structure of metropolitan or large urban communities. Theoretically of interest is whether in contemporary metropolitan areas a primary nucleus, as well as other smaller nuclei, can be clearly delineated and whether their relationships in a network can be meaningfully examined. In several officially-defined metropolitan areas in the United States, including Chicago, data on employment and commuting from the 1990 census were assigned to every traffic analysis zones (TAZs), specially defined subareas. For these TAZs, the employment-residence (ER) ratio – the ratio of the number of workers working in the TAZ to the number workers residing in the TAZ – was calculated to determine the extent that the TAZ was more an employment area than a residential area. TAZs with a high ER were identified and considered part of the nuclei of the metropolitan area. For two of the metropolitan areas, including Chicago, several contiguous TAZ clearly constituted the downtown, satellite, peripheral, and arterial financial, governmental, and manufacturing nuclei. Issues of contiguity and commuting among the nuclei remain.

Background

For well over a century, demographers, sociologists, and geographers have been trying to understand the spatial structure of human communities influenced by changing transportation and communication technology and growing or declining population, particularly the nature of the center or centers of large metropolitan communities, focusing attention on the **nucleus** or possible **multiple nuclei** of these areas (Harris and Ullman, 1945; Hawley, 1950, 238-245; Hawley, 1986, 88-102). A metropolitan area encompasses those persons and activities intensely "interrelated and integrated with reference to daily requirements" by virtue of their diversity or differences (Hawley, 1950, 257). A metropolitan area performs significant coordinating functions through specialization, usually requiring sufficient population and infrastructure size (Hawley, 1950, 256-262; Hawley, 1986, 89-95). According to Hawley (1950, 270), although there may be many subcenters within a metropolitan area; "[o]f the network of interdependences in which the several centers of a communal complex are enmeshed, the largest or major center forms the core [or nucleus]. Concentrated there are communication agencies, financial and legal services, and the administrative offices of political, recreational, religious, and other services as well as of industry and commerce." The major or primary nucleus as well as all other nuclei of the metropolitan area are integral aspects of the metropolitan concept. With the population and areal growth of metropolitan areas over time, many secondary nuclei have developed, perhaps overtaking the original dominant nucleus. **Theoretically** of interest is whether in contemporary metropolitan areas a primary nucleus, as well as other smaller nuclei of metropolitan areas, can be clearly delineated and whether their relationships in a network can be meaningfully examined.

Similarly, from a **practical** perspective, being able to identify the nucleus or multiple nuclei of metropolitan areas is crucial for defining metropolitan areas. For this reason, in early 1990, the Office of Management and Budget of the United States Federal Government announced that it was undertaking a complete and systematic review of the concept and definitions of metropolitan areas in the United States. Since 1950, metropolitan areas were defined on the basis of large central cities as the core and added counties based on commuting patterns, except in New England where towns were used (Office of Management and Budget, 1990). In the United States, a central city is the city with the largest population in a metropolitan area and any other city which qualifies depending on population size, commuting patterns, and employment/residence ratio (U.S. Bureau of the Census, 1993a). Metropolitan areas have been used for presentation not only of basic population and housing statistics from the decennial censuses but also of crime, health, labor force, traffic, and other statistics in between censuses. They have provided the basis for significant theoretical studies of settlement patterns and social and economic change in the United States for five decades. With growth of suburban cores and changes in employment and traffic patterns, metropolitan areas as they have been delineated have grown increasingly cumbersome and unrepresentative of labor markets and economic-activity networks, and fail to cover the entire geographical area of the United States.

As part of this review, Alden Speare and William Frey (Speare and Frey, 1992, 76), identified several problems with the basic concepts for defining metropolitan areas. Among them:

[First], the old metropolitan area concept ... is too wedded to the requirement of one central city (or agglomeration) as a core. The need for high central densities no longer exists, and there is no reason why a modern nonagricultural settlement couldn't be developed around a set of dispersed nodal concentrations or even be entirely suburban in character while providing employment, shopping, and recreation for its inhabitants....

[Second], metropolitan areas are divided into only two fundamental parts – the central cities and the balance – and there is no explicit recognition of various categories of suburbs [or parts of central cities] with different densities or functional characteristics.

While in the last 50 years, metropolitan areas have been built around these central cities in general, over that time, however, central cities as a whole have become increasingly unsatisfactory as the core or center of a metropolitan area because they differ greatly in population size, percent of the built up area of the metropolitan area, population density; they are not homogeneous and have come to include many previous suburbs or in some cases are non-existent (Treadway, 1982, 1983, 1984, 1985, 1992, 1993).

Conversely, the types of population and economic activities necessary for coordination of the metropolitan area have been moving to the "suburbs" in recent decades and are no longer exclusively in the central city. More suburban office complexes have been developed, and in more urbanized areas, populations traditionally associated with the central city were found in the suburbs (Treadway, 1983, 1984, 1985). Researchers focusing on suburbs as business and employing centers, such as Frey and Speare (1992, 10-14), discuss at length "suburban employment patterns [of] local labor markets ... which exist

within broad expanse of suburbia." Garreau (1992), in his insightful journalistic account in *Edge City*, highlighted awareness of significant office, retail, and manufacturing centers in suburbs or non-downtown areas of central cities. Similarly, Hughes (1993) calls into question the traditional view of a single center or central city of metropolitan areas. Based on her study of the large suburban cities in 41 multinodal metropolitan areas using data from the 1980 census and 1982 economic censuses, she finds that many suburbs are taking on central-city roles such "that the metropolitan community is best viewed as a complex system of differentially dominant places" (1993, 417).

Since for 1980 and 1990, central cities did not serve well as the core of metropolitan areas, Treadway (1990a and 1990b) studied small subareas of central cities and suburbs instead of just the political central cities, showing such small subareas could be clearly identified. Some of these small subareas would qualify as part of the central core of a metropolitan area while others would be low in density and be primarily residential, rather than employing subareas, and not be part of the central core. With multi-nucleation in metropolitan areas, central cities were no longer "central." Officially defined central cities of metropolitan areas both overbound and underbound the real nucleus of a metropolitan area, depending on the specific metropolitan area.

Possible Alternatives to Central Cities

One alternative approach to defining cores of metropolitan areas considered in the United States (Office of Management and Budget, 1998, 70535) was:

to combine two characteristics, population and employment. This would involve calculating ratios that compare the number of individuals employed in a geographic area to the number of residents in the same area. The explicit use of such an employment measure in the definition of a core [of a metropolitan area] would be a logical extension of the use of another employment-related statistic, commuting patterns, to define those areas that are integrated with the core.

Despite this proposal for identifying explicit cores of metropolitan areas, the Metropolitan Area Standards Review Committee in the United States eliminated any consideration of using such precisely defined metropolitan cores in its 1999 October recommendations for changes in the standards for defining metropolitan areas. Instead, it proposed to use an urbanized area – a statistical area over 50,000 or more population based on density and contiguity of block groups around a city or town – as the nucleus of a metropolitan area (Office of Management and Budget, 2000). "The cores (*i.e.*, the densely settled concentrations of population) for this classification would be [U.S.] Census Bureau-defined urbanized areas ... identified in Census 2000" (Office of Management and Budget, 1999, 56630).

The problem with using such large, statistically consistent urbanized areas as the cores of metropolitan areas became apparent after the Metropolitan Area Standards Review Committee received feedback on the likely implications of actually delineating metropolitan areas using these urbanized areas. First, they noted in 2000 August in their final report and recommendations on changes for defining metropolitan areas (Office of Management and Budget, 2000, 51066):

Urbanized areas with very large populations can extend across multiple counties and even across state boundaries, and can contain several distinct employment and settlement centers. Although these centers are part of a single agglomeration of population and activity, the degrees of functional integration between them can vary. The provision of data for only the entire metropolitan area based on such large urbanized areas may mask demographic and economic variations that are important for data users and analysts.

Because of these problems of using the large urbanized area as the core, the Metropolitan Area Standards Review Committee recommended subdividing large metropolitan areas into metropolitan divisions, based on the number of workers and ratio of workers to employed residents in each county of a metropolitan area.

A second problem arose in practice as the committee tried to categorize metropolitan areas based on their cores. They realized (Office of Management and Budget, 2000, 51064):

Although commuting is measured from county to county, most workers commute to specific cores. When there are multiple cores within a [metropolitan area], each core plays a role in the qualification of outlying counties.... [T]his is a complex issue that, in part, is reflected in the ongoing debate regarding the current nature of urbanization and urban systems. In the past metropolitan areas tended to be dominated by a single core, consisting largely of a populous city and its adjacent densely settled suburbs. The dispersal of residential locations and economic activities that has occurred in some areas over the past 50 years, however, has resulted in multiple cores, each of which may provide specialized functions that contribute to the social and economic well-being of the entire area. The extent of the spheres of influence of the various cores may vary and overlap depending on the kinds of functions or services provided. One core may play a greater, or more dominant, role in organizing and influencing the social and economic activity of a particular [metropolitan area]. At the same time, its influence could be supplemented or possibly matched by additional cores within the same [metropolitan area]. The committee recommends further research on the functional integration of multiple, noncontiguous cores.

Employment Approach Using Traffic Analysis Zones

A difficulty in using small subareas to define appropriately the nuclei of metropolitan areas currently is that they have not routinely had employment and other economic data collected for them as has been done for central cities and large suburbs. For 1990, the Census Transportation Planning Package (CTPP), however, made tabulations on persons and their characteristics not only in small subareas, such as census tracts, block groups, and traffic analysis zones (TAZs), of **residence** but also of **employment**, and on **commuting** from residence to workplace between census tracts and TAZs (U. S. Bureau of the Census, 1993b).

Traffic analysis zones are specially defined small subareas in metropolitan areas for use for traffic planning. In many metropolitan areas, they are defined around major arterial roads both within the urban area and in the surrounding rural area. In the Chicago area, TAZs consist of approximate quarter sections (one-half mile [approximately 800 metres] on each side) except in central Chicago, where quarter-quarter sections (one-quarter mile [approximately 400 metres] on each side) are used (Christopher, Nam, and Rogus, 1993, 1). In all metropolitan areas, each block was assigned to the TAZ

in which the census-block centroid was located (Christopher, Nam, and Rogus, 1993, 15). Data on both population and housing, especially on employment and commuting, were assigned to each TAZ by the U. S. Bureau of the Census, as part of the special Census Transportation Planning Package supported by the Federal Highway Administration and the Federal Transit Administration.

Data

In this study of the feasibility of using employment data from small subareas to define multiple nuclei of a metropolitan area, traffic analysis zones (TAZs) were used from the small metropolitan areas of Bloomington-Normal, Springfield, and Kankakee, Illinois, and Clarksville, Tennessee. These metropolitan areas had the advantage of having a manageable number of TAZs which covered the entire metropolitan area. Bloomington-Normal was a local, familiar area. In addition, the Chicago, Illinois, metropolitan area, consisting of eight counties, provided a large metropolitan area for study.

Because the data were to be used for transportation planning, focusing on commuting or the journey to work, three separate files were created for each metropolitan area: one for persons and households who **reside** in each TAZ, one for persons who **work** in each TAZ, and one for **commuting** flows of workers between each TAZ. Thus, the data on employment, occupation, industry, class of worker, and journey to work were given for **workers** 16 years and over, "that is, members of the Armed Forces and civilians who were at work during the reference week," the "calendar week preceding the date on which the respondents completed their questionnaires or were interviewed by enumerators" (U. S. Bureau of the Census, 1993a), **not** on all persons 16 years and over who were employed.

Workers were coded to the most detailed geographical level (census tract and block) from information given for the worker on location of work. Because of incomplete, illegible, or inaccurate responses or incomplete reference materials, including incomplete address ranges in the TIGER file, of the U. S. Bureau of the Census, not all workers could be assigned to a workplace TAZ. Where there were no tract or block records to be used, workers were assigned to a work place TAZ randomly unless 1) more than 30 percent of the blocks within a county or place had insufficient address ranges or 2) more than 30 percent of the workers could not be coded to a tract and block within a place. In this situation, workers were assigned to **default** TAZs in a complicated fashion depending on whether the place or county of workplace of the worker could be determined. For details, see Boertlein, *et al.*, 1993.

Procedures

As a result of these difficulties, not all workers were assigned to an actual TAZ of work, although they were workers in the metropolitan area. In order to account for these workers in TAZs of the metropolitan area, I arbitrarily assigned them to an **actual** work TAZ **proportionately** to the number of workers working in each TAZ. In the Bloomington-Normal metropolitan area, for instance, 9.8 percent of the workers had been assigned to default TAZs; thus, the number workers in each TAZ was multiplied by 1.098 to obtain an approximate number of workers working in the TAZ. Kankakee had the highest proportion of workers not assigned to workplace TAZ, 34 percent, while Chicago had the lowest with four percent.

To identify whether each TAZ was an employment rather than a residential subarea, I merged the residential and workplace files. Some of the TAZs had no workers, even workers living at home **working** in them, and these TAZs were thus completely **residential** TAZs. In these metropolitan areas, between eight percent (Springfield) and 33 percent (Chicago) of the TAZs were completely residential. Other TAZs, which had workers **working** in them had no workers or no persons (including non-

workers) **residing** in them; they were predominately or completely employment TAZs. Ten percent of the TAZs in the Bloomington-Normal metropolitan area, for instance, were such subareas and prime candidates to be part of the nuclei of metropolitan areas.

As a measure of the extent that a TAZ was more an **employment** subarea than a **residential** subarea, the ratio of the **adjusted number of workers working in the TAZ to the number workers residing in the TAZ**, called the **Employment-residence (ER) ratio** was used. Those TAZs with less than five workers residing in the TAZ were given special arbitrary values of the Employment-residence ratio to avoid having an inflated value because of a small denominator. If a TAZ with five or fewer workers **living** in it had five or fewer workers **working** in the TAZ, the Employment-residence ratio was assigned as 0 since the TAZ was clearly not a large employment subarea; while if the number of workers working in the TAZ were greater than five, the Employment-residence ratio was given a value of 10 since it was basically an employment TAZ. With additional experience from other metropolitan areas, a higher cut off of number of workers **residing** in the TAZ might be determined to be a more reasonable value. In the Bloomington-Normal metropolitan area, for instance, 11 percent of the TAZs had five or fewer workers residing in them, while another four percent had between six and ten workers living in them.

Results

According to the experience in these metropolitan areas, small subareas, such as TAZs, can be identified as being primarily employment subareas that might be used as the basis for identifying multiple nuclei of a metropolitan area. Table 1 shows the frequency, percent, and cumulative percent of TAZs by Employment-residence ratio.

Between 60 and 80 percent of the TAZs in these metropolitan areas had Employment-residence ratios below unity; these are clearly residential subareas and not part of employment nuclei of the metropolitan area. At the other extreme, between 11 and 22 percent of the TAZs are clearly predominately-employment subareas with more than five times as many workers working in the TAZ than living there; they could form part of the nucleus of the metropolitan area. Some of the other TAZs with more workers working in them than workers residing in them might also be part of the nuclei of the metropolitan area, depending on the contiguity to the predominantly-employing TAZs and interaction with them.

For the TAZs in the Bloomington-Normal area, I was able to map the predominately **Worker** TAZ. The downtown areas of Bloomington and Normal are in the center of the metropolitan area along with the national State Farm Insurance Company headquarters and shopping malls on the east, Mitsubishi Motors automobile factory on the west, and industrial areas on the south. If those TAZs with ratios between 3.00 and 4.99 are added, Illinois State University and Illinois Wesleyan University are included. The addition of TAZs with ratios between 2.00 and 2.99 represent other commercial areas. All together, many nuclei, widely separated, exist, but the relationship between the nuclei in terms of developing a core for defining a metropolitan area is not clear from the analysis so far. In the Chicago area, I could identify some of the cores by mapping adjacent qualifying TAZ, as, for example, Chicago's loop, industrial and retail centers along arterial highways, and the downtowns of several suburbs (Treadway, 2000).

In no metropolitan area was I able to determine satisfactorily what the cut-off value of the ER ratio that clearly distinguished the TAZs which were part of the nucleus of a metropolitan area from

those which were not. In addition, I have not yet been able to examine the importance of using contiguity or commuting among the TAZ to identify the actual extent or location of the primary and other nuclei of metropolitan areas.

Conclusion and Additional Research

The feasibility of using small subareas of metropolitan areas, such as TAZs (or tracts or block groups), to define the multiple employment nuclei of a metropolitan area has been shown by this research. The data are available for most metropolitan areas in the United States, and they can be used to distinguish small subareas as significantly-employing subareas. While these multiple nuclei may not cluster at the center of the metropolitan area any more, they are distinctly different on the ratio of employment to residents working from other predominately-residential subareas. Such data will also be available from the 2000 United States Census in 2003 and can be used to identify multiple nuclei in metropolitan areas for 2000.

Several questions still need to be resolved, however, in using data from the Census Transportation Planning Package to determine subareas belonging to multiple nuclei of metropolitan areas..

First, more metropolitan areas need to be studied to determine the **level** of the Employment-residence ratio to be used to identify those TAZs which are a part of the nuclei of the metropolitan area. Both larger areas, such as New York and Los Angeles, and other smaller areas with different urban structures need to be included, and the procedure needs to be applied to 2000 census data.

Second, the nature of the contiguity of the subareas needs to be examined. Should there be a minimum number of workers in contiguous, combined employment subareas for them to be included in the multiple nuclei?

Third, to what extent does commuting between these employment subareas take place, and is some amount of interaction between noncontiguous employment subareas necessary for them to be a part of the nucleus of the same metropolitan area?. Data on commuting between TAZs could be used to establish commuting criteria.

Fourth, what other criteria, besides being a predominately employing nucleus, should be used? For instance, should the occupation of the workers working in the nucleus be non-agricultural or non-extractive? Should other social and economic factors be taken into consideration? Should other daytime population, such as students, shoppers, and other non-employed persons, be taken into account? How should open places, such as parks, recreational facilities, and other important urban facilities, which may have few workers in them, be handled?

This research has explored the procedures that can be used with small subareas (TAZs) of metropolitan areas to define more suitable multiple nuclei of metropolitan areas than central cities. While it has found that delineating more viable alternative multiple nuclei of metropolitan areas based on employment is **feasible** with existing detailed data, many problems remain.

Note on maps and graphs

Additional maps and graphs to go with this paper will be available at the S29 session on "Spatial Demographic Analysis" at the International Union of Scientific Study of Population Conference in Salvador de Bahia, Brazil, 2001 August 23 or from the author at the email address treadway@ilstu.edu.

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Table 1: Frequency and Percent by Employment Residence Ratios of Traffic Analysis Zones in Selected Metropolitan Study Areas, 1990

Employment-Residence Ratio	Frequency	Percent	Cumulative Percent
Bloomington-Normal, Illinois			
0.00	40	21.5	21.5
0.01 – 0.99	82	44.1	65.6
1.00 – 1.99	16	8.6	74.2
2.00 – 2.99	10	5.4	79.6
3.00 – 3.99	9	4.8	84.4
4.00 – 4.99	2	1.1	85.5
5.00 and over	27	14.5	100.0
Total	186	100.00	
Springfield, Illinois			
0.00	19	8.2	8.2
0.01 – 0.99	119	51.5	59.7
1.00 – 1.99	19	8.2	68.0
2.00 – 2.99	5	2.2	70.1
3.00 – 3.99	6	2.6	72.7
4.00 – 4.99	11	4.8	77.5
5.00 and over	52	22.5	100.0
Total	231	100.0	
Kankakee, Illinois			
0.00	33	24.1	24.1
0.01 – 0.99	59	43.1	67.2
1.00 – 1.99	13	9.5	76.6
2.00 – 2.99	5	3.6	80.3
3.00 – 3.99	1	0.7	81.0
4.00 – 4.99	4	2.9	83.9
5.00 and over	22	16.1	100.0
Total	137	100.0	
Clarksville, Illinois			
0.00	7	11.7	11.7
0.01 – 0.99	36	60.0	71.7
1.00 – 1.99	4	6.7	78.3
2.00 – 2.99	2	3.3	81.3
3.00 – 3.99	0	0.0	81.3
4.00 – 4.99	4	6.7	88.3
5.00 and over	7	11.7	100.0
Total	60	100.0	
Chicago, Illinois			
0.00	3315	33.4	33.4
0.01 – 0.99	4441	44.8	78.2
1.00 – 1.99	669	6.7	85.0
2.00 – 2.99	216	2.2	87.2
3.00 – 3.99	116	1.2	88.3
4.00 – 4.99	86	0.9	89.2
5.00 and over	1071	10.8	100.0
Total	9914	100.0	