A Spatial Analysis of Job Openings and Access in a US Metropolitan Area

Qing Shen

Project Report
The New England University Transportation Center
Massachusetts Institute of Technology
77 Massachusetts Avenue, Room 1-235
Cambridge, MA 02139, USA

June 1999

Acknowledgements

The author would like to acknowledge the research funding (Project No. MITR10-7) provided by the New England University Transportation Center. Hideo Sakamoto capably prepared the maps in this paper. The author wishes to thank Frank Levy for his suggestions, Harry Holzer for providing useful information about job turnover and vacancy duration in US metropolitan areas, and William Wilson for his helpful comments on research findings reported in this paper.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	June 1999	Final, Sept 97 - Aug 98

4. TITLE AND SUBTITLE
A Spatial Analysis of Job Opening and Access in a US Metropolitan Area

5. FUNDING NUMBERS
DTRS95-G-0001

6. AUTHOR(S)
Qing Shen

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Massachusetts Institute of Technology
77 Mass. Ave. Room 9-526
Cambridge, MA 02139

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
New England (Region One) UTC
MIT
77 Mass. Ave. Room 1-235
Cambridge, MA 02139

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

To design effective strategies for removing spatial barriers to low-income workers' access to economic opportunities, it is essential to reexamine the "geography of opportunity." This paper presents a study of spatial distribution of job openings and of spatial variation in job accessibility in the Boston Metropolitan Area. The research methodology has three main components: (1) estimation of the number of job openings, (2) measurement of job accessibility, and (3) analysis and visualization of spatial patterns of job openings and accessibility. The most striking finding is that, despite decades of employment decentralization, job openings—including those suitable for less-educated job seekers—are still relatively concentrated in the central city. This is due to the fact that the great majority of openings are job vacancies resulting from turnover; the spatial concentration of turnover reflects the spatial concentration of current employment. A related finding is that, for a given transportation mode, less-educated job seekers who reside in the central city still have, on average, somewhat better access to job openings than those who reside at the periphery of the metropolitan area. However, accessibility differentials among locations are small as compared to accessibility differentials between transportation modes. For job seekers who can travel by car, the majority of residential locations will allow them to have an accessibility level higher than the average. For job seekers who depend on public transit, on the other hand, very few residential locations will allow them to have an above-average accessibility level. These findings imply that transportation mobility improvement is, whereas residential dispersal is not, a potentially effective strategy for overcoming spatial separation between economic opportunities and the economically disadvantaged population, including welfare recipients, in US metropolitan areas.

14. SUBJECT TERMS	15. NUMBER OF PAGES
Job openings, Employment accessibility, Spatial barriers, Welfare reform, Transportation planning	34
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT

Exhibit C

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.

4. Title and Subtitle

A Spatial Analysis of Job Openings and Access in a US Metropolitan Area

5. Report Date

June 1999

6. Performing Organization Code

7. Author(s)

Qing Shen

8. Performing Organization Report No.

9. Performing Organization Name and Address

Massachusetts Institute of Technology
77 Massachusetts Avenue, Room 9-526
Cambridge, MA 02139

10. Work Unit No. (TRAIS)

11. Contract or Grant No.

DTRS95-G-0001

12. Sponsoring Agency Name and Address

New England (Region One) UTC
Massachusetts Institute of Technology
77 Massachusetts Avenue, Room 1-235
Cambridge, MA 02139

13. Type of Report and Period Covered

Final Report
September 1997 - August 1998

14. Sponsoring Agency Code

15. Supplementary Notes

Supported by a grant from the US Department of Transportation, University Transportation Centers Program

16. Abstract

To design effective strategies for removing spatial barriers to low-income workers' access to economic opportunities, it is essential to reexamine the "geography of opportunity." This paper presents a study of spatial distribution of job openings and of spatial variation in job accessibility in the Boston Metropolitan Area. The research methodology has three main components: (1) estimation of the number of job openings, (2) measurement of job accessibility, and (3) analysis and visualization of spatial patterns of job openings and accessibility. The most striking finding is that, despite decades of employment decentralization, job openings—including those suitable for less-educated job seekers—are still relatively concentrated in the central city. This is due to the fact that the great majority of openings are job vacancies resulting from turnover; the spatial concentration of turnover reflects the spatial concentration of current employment. A related finding is that, for a given transportation mode, less-educated job seekers who reside in the central city still have, on average, somewhat better access to job openings than those who reside at the periphery of the metropolitan area. However, accessibility differentials among locations are small as compared to accessibility differentials between transportation modes. For job seekers who can travel by car, the majority of residential locations will allow them to have an accessibility level higher than the average. For job seekers who depend on public transit, on the other hand, very few residential locations will allow them to have an above-average accessibility level. These findings imply that transportation mobility improvement is, whereas residential dispersal is not, a potentially effective strategy for overcoming spatial separation between economic opportunities and the economically disadvantaged population, including welfare recipients, in US metropolitan areas.

17. Key Words	18. Distribution Statement
Job Openings Employment Accessibility Spatial Barriers Transportation Planning Welfare Reform Spatial Analysis and Visualization	

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
		34	$ 15,000

Form DOT F 1700.7 Reproduction of form and completed page is authorized

I. INTRODUCTION

An important objective of antipoverty policy in the United States is to reduce spatial separation between economic opportunities and low-income people who seek such opportunities. Hughes (1995) identifies three basic strategies for helping low-income people to overcome spatial obstacles. One strategy is to enable them to relocate their residence in or near job-rich communities. This strategy is often equated with housing dispersal because its proponents tend to believe that the suburbs have more jobs suitable for less-educated workers. A second strategy is to create employment opportunities in low-income communities. A third strategy is to improve transportation between their residential locations and potential job locations. Noticeable efforts associated with these alternative strategies are, respectively, housing projects and vouchers for low-income households, community economic development programs such as enterprise zones, and vanpool and transit services linking the central city to suburban employment centers.

To assist policy makers in evaluating and improving these strategies, urban researchers must gain a deeper understanding of the "geography of opportunity." We need to examine more closely the spatial distribution of economic opportunities that do not require a high level of educational attainment, the spatial distribution of less-educated workers who seek such opportunities, and the spatial variation of accessibility to such opportunities. We need more fine-grained descriptions and analyses of the existing conditions (Jencks and Mayer, 1990).

Current welfare reform has added great urgency to the task. The Personal Responsibility and Work Opportunity Reconciliation Act of 1996 has terminated the federal government's open-ended welfare support to needy families. The new legislation requires work participation of all adult welfare recipients after they receive cash assistance for two years. Undoubtedly, the welfare reform is faced with major barriers, which include spatial barriers. A high percentage of adult welfare recipients are single females with dependent children but without a car. It is difficulty for them to find jobs that do not require an intolerable amount of travel time or cost. Strategies for increasing welfare recipients'

accessibility to job opportunities, therefore, should be considered an important component of urban policies aimed at facilitating the welfare-to-work transition (Blumenberg and Ong, 1998; Lacombe, 1997; Laube, *et al.*, 1997; Rich and Coughlin, 1998; Wachs and Taylor, 1998). A good understanding of the "geography of opportunity" is a prerequisite for designing effective strategies.

For job seekers, including welfare recipients, job openings—positions that are currently available—are the most relevant economic opportunities. Therefore, it is essential for urban researchers to ask the following questions:

1) How are job openings, ones that are suitable for less-educated workers, spatially distributed in the metropolitan area?
2) What are the distinctive patterns of variations in accessibility to these job openings?

This research is an effort to answer these questions, which are seemingly simple but are actually rather challenging because there are no systematically collected data on intra-metropolitan distribution of job openings. In the remaining sections of the paper, the author will review current literature, describe the research methodology, and report the findings. Although the analysis is based on the case of the Boston Metropolitan Area, the findings shed new light on the search for approaches to enhancing less-educated workers' access to opportunities. In particular, they suggest that residential dispersal is unlikely to be effective as a strategy for lifting spatial barriers in the dispersing metropolitan economy. On the other hand, they indicate the growing importance of transportation mobility strategy for overcoming spatial separation between economic opportunities and the economically disadvantaged population.

II. IMPORTANCE OF EXAMINING JOB OPENINGS

A large volume of research on spatial patterns of residence, employment, and commuting in US metropolitan areas has been completed over the past three and a half decades. Researchers have drawn different, and in many cases conflicting, conclusions on where job opportunities for less-educated workers are located and how to improve access to

such opportunities. Instead of attempting a comprehensive review of the literature, the discussion here is focused on several recent studies by which the disagreement is clearly illustrated.

Kasarda (1995) shows that, while a high percentage of less-educated workers still live in low-income neighborhoods in the central city, jobs suitable for them are increasingly decentralized. Furthermore, he indicates that US metropolitan areas are undergoing a fundamental industrial transition and, as a result of that process, the central-city economy is becoming more and more information-intensive. He argues that these two general trends have caused both spatial mismatch and skill mismatch, which together have put less-educated workers who reside in the central city at a disadvantage with respect to job access. This view is widely shared among urban researchers (Holzer, 1996; Hughes, 1995; Kain, 1992; Rosenbaum, 1995; Wilson, 1996). Many of these researchers argue that public policy should be aimed at relocating low-income households from the central city to the suburbs through promoting affordable suburban housing.

Other researchers, however, indicate that less-educated workers living in the central city have no disadvantage in job access, when compared with otherwise comparable workers living in suburbs. Taylor and Ong (1995) show that existing disparities in accessibility among workers are largely caused by their use of different transportation modes. Shen (1998) finds that, in the case of the Boston Metropolitan Area, the central city location actually still gives low-income residents some advantage in job access. But this location advantage, according to his empirical measurement, is relatively modest and is more than offset by the low level of automobile ownership among low-income households located in the central city. These researchers share the view that transportation mobility, rather than residential location, is the key determinant of the degree to which low-income workers seeking economic opportunities are faced with spatial barriers. Their findings imply that the common approach to the diagnosis and treatment of spatial mismatch, which focuses on the residential location factor, needs modification.

What has caused this disparity? A close examination of the research designs suggests that

the disagreement may be partly attributed to the different ways in which economic opportunities are measured. Some researchers, Kasarda (1995) for example, use employment changes (growth, decline, and relocation) as the basis for analyzing spatial distribution of job opportunities and spatial variation in job accessibility. Others, Shen (1998) for example, use employment levels instead. Given the fact that new jobs are spatially much more dispersed than pre-existing jobs, it is not surprising that the former finds the central city to be a disadvantaged residential location with respect to employment access, whereas the latter finds the opposite to be true.

Which approach is preferable? If the objective is to understand variations in accessibility for all less-educated workers, employment levels should undoubtedly provide an appropriate measure of opportunities. On the other hand, if the objective is to understand variations in accessibility for only those less-educated workers who are unemployed and are seeking jobs, neither approach will be appropriate. Economic opportunities for job seekers consist of two categories of job openings—one comes from employment growth and the other comes from turnover. Data on employment changes capture growth but not turnover, whereas data on employment levels captures turnover but not growth. Neither measure alone provides a complete picture of the total economic opportunities for less-educated job seekers.

Because unemployed workers are the primary target of antipoverty policy in general and of current welfare reform in particular, it is imperative to study job openings. It is essential to investigate the spatial distribution of job openings that are suitable for less-educated workers and, subsequently, reexamine patterns of spatial variations in employment accessibility.

III. RESEARCH METHODOLOGY

The research methodology has three main components: (1) estimation of the number of job openings, (2) measurement of accessibility to job openings, and (3) analysis and visualization of spatial patterns of job openings and accessibility. Each of these

components will be described and discussed.

Estimation of the Number of Job Openings

The objective is to obtain information on intra-metropolitan distribution of job openings, at an adequate level of spatial resolution. Given the fact that governmental agencies in charge of economic censuses do not collect spatially disaggregated data on job openings, alternative ways to obtain the information need to be explored. One conceivable approach is to draw a probability sample from all employers in a metropolitan area and conduct a questionnaire survey. Based on the responses, the researcher can find out the number, education and skill requirements, and other characteristics of job openings in various geographic locations within the metropolitan area. However, in order to gather the data at a satisfactory level of spatial resolution, a very large sample is needed, which translates into a requirement for huge amounts of financial and time resources. Therefore, this approach is often not practical.

A similar, but more realistic, approach is to survey only those employers who are actively seeking employees through job advertisements in newspapers, web sites, and other media. As compared with the previous approach, it requires a smaller sample and simplifies the sampling procedure. The primary shortcoming is that it excludes from the sample all employers who do not advertise their job openings. A good example of an application of this approach is found in a recent study of economic opportunities and job accessibility in Metropolitan Atlanta (Rich and Coughlin, 1998). The researchers sent questionnaires to approximately 3,000 employers who were advertising job openings in the newspaper and received 750 completed responses. The data obtained from the survey enabled them to gain useful insights into the composition and spatial distribution of job openings. However, because this approach excludes from the sample an unknown number of employers who are actually hiring, it does not usually lead to a systematic measurement of spatial variations in accessibility to job openings.

Another alternative, which can lead to a systematic measurement of spatial variations in

accessibility to job openings, is to estimate the numbers of job openings for different geographic locations within the metropolitan area. The estimation, of which the details are described in the following paragraphs, is based on spatially disaggregated data on both employment levels and employment changes. This approach does not require a special survey of employers and therefore is much more economical than the previous ones. Its major shortcoming, obviously, is that the resulting data consist of estimates rather than observations. In spite of the shortcoming, however, this approach is useful because the estimates depict a relatively complete picture of spatial patterns of job openings in a metropolitan area, which can complement insights gained from a survey of employers.

Job openings consist of opportunities created by employment growth and opportunities created by turnover. Formally, job openings ($O_{i(t)}$) in geographic location *i* at time *t* can be expressed by the following equation:

$$O_{i(t)} = O_{i(t)}^{growth} + O_{i(t)}^{turnover} \quad (1)$$

where $O_{i(t)}^{growth}$ is the number of job openings that come from employment growth, and $O_{i(t)}^{turnover}$ is the number of job openings that come from turnover, in geographic location *i* at time *t*. It is important to note that employment growth can have negative values (i.e., employment decline and/or relocation), which means that $O_{i(t)}^{growth}$ can be negative.

In order to quantify these two components of job openings, it is essential to estimate average rates of employment growth and turnover and average duration of job vacancies. Using month as the unit of measurement for time, the product of monthly employment growth and vacancy duration yields the value of the first component of job openings. The product of monthly turnover and vacancy duration yields the value of the second component of job openings.

Under normal macroeconomic conditions, average vacancy duration in the US is roughly 0.5 month, or 15 days. Assuming that the employment level increases or decreases by a

constant amount every month during a time period, job openings due to employment growth can be estimated as follows:

$$O_{i(t)}^{growth} = \frac{E_{i(t)} - E_{i(t')}}{(t - t') \times 12 \text{ month}} \times 0.5 \text{ month} \quad (2)$$

where

t is the ending point (year) of the time period;

t' is the starting point (year) of the time period;

$E_{i(t)}$ is employment level in geographic location *i* at the ending time;

$E_{i(t')}$ is employment level in geographic location *i* at the starting time.

Estimation of the number of job openings created by turnover is more challenging. The difficulty is caused by the lack of systematically collected data on turnover. However, there are some available data that are useful for making sound estimates. Until 1981, the US Bureau of Labor Statistics (BLS) had annual surveys on turnover in the manufacturing sector. The data indicated that average *monthly* turnover rate was roughly 4 percent if all components—quits, discharges, and layoffs—were taken into consideration; it was close to 3 percent if only quits and discharges were taken into consideration. It is important to note that the latter is more relevant to this study because quits and discharges lead to job openings, whereas layoffs do not.

Some recent studies provided more updated data on turnover. Anderson and Meyer (1994) calculate an average *quarterly* turnover rate of 23 percent across all industries. Their figure suggests a monthly rate that is considerably higher than the figure reported by the BLS. However, Anderson and Meyer do not separate the portion of turnover caused by layoffs. If this portion were excluded from their calculation, the resulting turnover rate would be reduced. Holzer (1996), on the other hand, indicates that average *annual* turnover rate across manufacturing, retail, and service is roughly 21 percent. Holzer's calculation is based on quits and discharges only. If converted into a monthly

rate, this figure would be similar to the figure reported by the BLS.[1]

Taken together, it is reasonable to assume that under normal macroeconomic conditions, quits and discharges create a *monthly* turnover rate of 2 – 4 percent. Using a turnover rate of 3 percent, i.e., the middle point of the range, job openings created by turnover are estimated as follows:

$$O_{i(t)}^{turnover} = 3\% \text{ per month} \times E_{i(t)} \times 0.5 \text{ month} \tag{3}$$

Measurement of Job Accessibility

Over the last four decades, urban researchers have developed many alternative accessibility indicators. The demand-adjusted indicator, proposed initially by Weibull (1976) and extended recently by Shen (1998), is especially suitable for measuring job seekers' level of accessibility. The following two equations are, therefore, used to calculate accessibility for job seekers who are, respectively, automobile drivers and captive transit riders:

$$A_i^{auto} = \Sigma_j \frac{O_{i(t)} \times f(C_{ij}^{auto})}{\Sigma_k [\alpha_k P_{k(t)} \times f(C_{kj}^{auto}) + (1 - \alpha_k) P_{k(t)} \times f(C_{kj}^{tran})]} \tag{4}$$

$$A_i^{tran} = \Sigma_j \frac{O_{i(t)} \times f(C_{ij}^{tran})}{\Sigma_k [\alpha_k P_{k(t)} \times f(C_{kj}^{auto}) + (1 - \alpha_k) P_{k(t)} \times f(C_{kj}^{tran})]} \tag{5}$$

where

A_i^{auto} and A_i^{tran} are accessibility scores for job seekers who are automobile drivers and captive transit riders, respectively, living in location i; $i = 1, 2, \ldots, N$;

$O_{i(t)}$ is the number of job openings in location j at time t; $j = 1, 2, \ldots, N$;

$f(C_{ij}^{auto})$ and $f(C_{ij}^{tran})$ are impedance functions for automobile drivers and transit riders,

[1] Since many jobs have multiple turnovers during a year, the monthly turnover rate is considerably higher than 1/12 of the annual turnover rate. See Anderson and Meyer (1994) for a more thorough discussion of this issue.

respectively, traveling between i and j;

$P_{k(t)}$ is the number of job seekers living in location k at time t; $k = 1, 2, \ldots, N$;

$f(C_{kj}^{auto})$ and $f(C_{kj}^{tran})$ are impedance functions for automobile drivers and transit riders, respectively, traveling between k and j;

α_k is the percentage of households in location k that own at least one motor vehicle.

Equation (4) and equation (5) together reflect essentially each worker's proximity to job openings for which he or she is qualified, relative to the number of workers competing for these positions. Proximity is measured by required travel time, which is determined jointly by travel distance and travel mode.

A good measure of the number of job seekers living in each location is the number of unemployed workers living in that location. Because the focus of this study is on economic opportunities and job access for less-educated workers, it is desirable to estimate the number of unemployed workers in each location who are seeking positions that require relatively little formal training. Unfortunately, information about the composition of unemployed workers is usually not available for small geographic areas. Therefore, an estimation is made, which involves two basic steps. First, less-educated job seekers are defined as people who seek positions in sales, services, and labor-intensive occupations.[2] Second, the number of less-educated job seekers living in each location is approximated on the basis of either of two alternative assumptions. One assumption is that the occupational distribution of unemployed residents resembles the occupational distribution of employed residents for which information is available. The other assumption is that all unemployed workers residing in each location are seeking jobs that require relatively little education.

Similarly, it is desirable to estimate the number of job openings in each location that are suitable for less-educated job seekers. As an approximation, only jobs in sales, services,

[2] The Standard Occupational Codes (SOC) for these occupations are SOC 243-302 (sales), SOC 403-472 (services), SOC 473-502 (farming, forestry and fishing), and SOC 703-902 (construction and machine operation).

and labor-intensive occupations are included in the calculation of job openings.[3]

Available data on automobile ownership only measure the overall percentage of households in each location that have one or more motor vehicles; they do not provide any information about the level of automobile ownership among less-educated job seekers. Once again, there are two basic approaches to making the approximation. The first approach is to assume that job seekers living in each location have the same level of automobile ownership as do the rest of residents in the location. The alternative approach is to assume that all job seekers have a same level of automobile ownership, for example, 50 percent, regardless of where they live.

There are many possible ways to specify the travel impedance function. To make the analysis transparent, this study uses the travel time threshold function, which has the simplest form. With a threshold travel time of C, the value of $f(C_{ij}^{auto})$ is 1 when C_{ij}^{auto} is less than C; it is 0 otherwise. The value of $f(C_{ij}^{tran})$ is similarly assigned. To find out whether the results are sensitive to the definition of the threshold time, three alternative values of C, 15, 30, and 45 minutes, are used.[4]

Shen (1998) shows that the expected value of accessibility scores calculated using equation (4) and equation (5) equals the ratio of the total number of opportunities to the total number of opportunity seekers in the metropolitan area.[5] In the context of this study, the expected value is the ratio of the sum of job openings to the sum of job seekers. The ratio provides a benchmark for examining how the accessibility to job openings varies among residential locations and between travel modes. Note that here and in the remainder of this paper, in order to make the writing less wordy, the term "job openings"

[3] See the previous footnote for detailed information on which occupations are considered as suitable for less-educated job seekers.

[4] These different threshold travel times represent different assumptions about how far workers are willing to commute. The same alternative values were used in Ellwood (1986). It is important to compare results obtained based on these alternative assumptions because different workers have different job-searching and commuting behaviors. For example, women, especially those who have young children to take care of, tend to make short trips (Hanson and Pratt, 1995; Rosenbloom and Burns, 1993). This implies that women with dependent children tend to look for jobs that are located close to home.

[5] The expected value of accessibility $A = O / P$, where $O = \Sigma_j O_{j(t)}$ and $P = \Sigma_k P_{k(t)}$.

is often used to denote job openings suitable for less-educated job seekers, and the term "job seekers" is often used to denote less-educated job seekers.

Visualization of Spatial Patterns of Job Openings and Accessibility

When a metropolitan area is represented by a large number of locations (zones), visualization through mapping becomes highly effective for identifying spatial patterns of job openings and accessibility. Geographic information systems (GIS) provide an effective tool for this purpose. The three-dimensional (3-D) representation capability of GIS is especially powerful in visualizing variables, such as employment and people in a metropolitan area, that show highly skewed spatial distributions. Three sets of maps will be produced. The first set of maps depicts the spatial distributions of job openings created by employment growth, of job openings created by turnover, and of the sum of these two components. The second set of maps shows the spatial distribution of job seekers and the locations of opportunity-rich and opportunity-poor areas. The third and final set of maps describes spatial variations in the level of accessibility to job openings, controlling for the effects of different travel modes.

Because the geographic size of these locations (zones) varies substantially, spatial distributions of job openings and job seekers are best represented visually by density maps. In 3-D representation, densities of job openings and job seekers are depicted by heights. The volumes, each a multiplication of height and area, realistically depict the spatial distributions of job openings and seekers.

The Case Study, the Data, and Computation

The Boston Metropolitan Area is examined as a case study. A total of 775 transportation analysis zones spatially represent this metropolitan area, which covers more than two thousand square miles of land and accommodates more than 4 million people.[6]

[6] The 1980 geographic boundary contained 775 zones. But the 1990 boundary, which was expanded,

Because 1990 was the most recent year in which spatially disaggregated employment data were systematically collected, the year 1990 is considered in this study as the ending point (t) of the time period of concern. The starting point (t') of the time period is 1980. The length of the time period, which is the denominator of equation (2), is 120 months.

Data on employed workers by occupation by residential location, for 1980 and 1990, are extracted from the US Census Bureau's Summary Tape Files 3A (STF3A). Also extracted from STF3A are data on unemployment and automobile ownership by residential location. Data on employment by occupation by work location, for 1980 and 1990, originate from the US Census Bureau's Journey-to-Work tabulations. Zone-to-zone travel-time matrices for automobile and transit, essential for calculating travel impedance for each mode, are obtained from the Central Transportation Planning Staff, which is in charge of transportation planning in the Boston Metropolitan Area.

Accessibility scores are calculated using a program written in the C language. Maps are generated using the GIS software ArcView 3-D Analyst.

IV. PRIMARY FINDINGS

The Composition of Job Openings

It is useful to first look at the overall picture. Between 1980 and 1990, the Boston Metropolitan Area added roughly 390,000 jobs. Based on equation (2), it is estimated that on a typical day during the time period, there were roughly 1,630 job openings due to employment growth. It is also estimated that only 18 percent of these openings—approximately 290 new positions—were in sales, services, and labor-intensive occupations.[7] These new jobs are considered suitable for less-educated job seekers.

---

contained 787 zones. To analyze employment growth, this study focuses on the 775 zones that are included in both 1980 and 1990 data.

[7] The estimated number of new positions would be roughly 440 if the decline of manufacturing

The corresponding figures of job openings created by turnover, which are estimated using equation (3), are much greater. On a typical day in 1990 there were roughly 31,280 job openings due to quits and discharges! Almost one third of them—approximately 10,400 positions—were in occupations suitable for less-educated job seekers.

Altogether, on a typical day in 1990, there were estimated 32,910 job openings in the Boston Metropolitan Area. Roughly 30 percent of them (10,690 positions) were suitable for less-educated job seekers.

Table 1. Estimated Job Openings in the Boston Metropolitan Area

	Positions Created by Growth	Vacancies Created by Turnover	Total Number of Job Openings
Total	1,630	31,280	32,910
Suitable for Less-Skilled	290	10,400	10,690

Table 1 summarizes these results. What is striking in these figures is that employment growth, in comparison with turnover, was only a minor source of job openings. It accounted for merely 5 percent of total job openings and less than 3 percent of job openings in sales, services, and labor-intensive occupations. Therefore, if an empirical study of job openings focused exclusively on employment growth, it would inevitably depict partial pictures and very likely draw incorrect conclusions.

The Spatial Distributions of Job Openings and Job Seekers

Table 2 describes the intra-metropolitan distribution of job openings that are suitable for less-educated workers, as well as the distribution of less-educated job seekers. Several important observations can be made. First, opportunities created by employment growth

employment, estimated to be –150 per day, were not taken into account.

are spatially much more dispersed than opportunities created by turnover. Only 6.9 percent of the former are located in the central city, whereas 20.4 percent of the latter are located in the central city. This is broadly consistent with observations made previously by numerous researchers, and indicates that the Boston case shares a fundamental similarity with other US metropolitan areas.

Table 2. Intra-Metropolitan Distribution of Less-Educated Job Seekers and Job Openings Suitable for Them

	Whole Metropolitan Area	Within the City of Boston	Outside the City of Boston
Positions Created by Growth	290	20 (6.9%)	270 (93.1%)
Vacancies Created by Turnover	10,400	2,120 (20.4%)	8,280 (79.6%)
Job Openings for the Less-Educated	10,690	2,140 (20.0%)	8,550 (80.0%)
Less-Educated Job Seekers	50,480	10,650 (21.1%)	39,830 (78.9%)

Second, because turnover is the dominant contributor of job openings, the spatial distribution of opportunities reflects primarily the distribution of turnover. Of all job openings in the Boston Metropolitan Area, 20.0 percent are located in the central city. It is worth noting that this percentage is similar to the one that Rich and Coughlin (1998) found in the Atlanta case through their survey of employers.

Third, less-educated job seekers are slightly more concentrated in the central city than are the job opportunities suitable for them. 21.1 percent of less-educated job seekers in this metropolitan area are located in the central city, in comparison with 20.0 percent of job opportunities. The issue of whether or not this implies that central-city residents have a

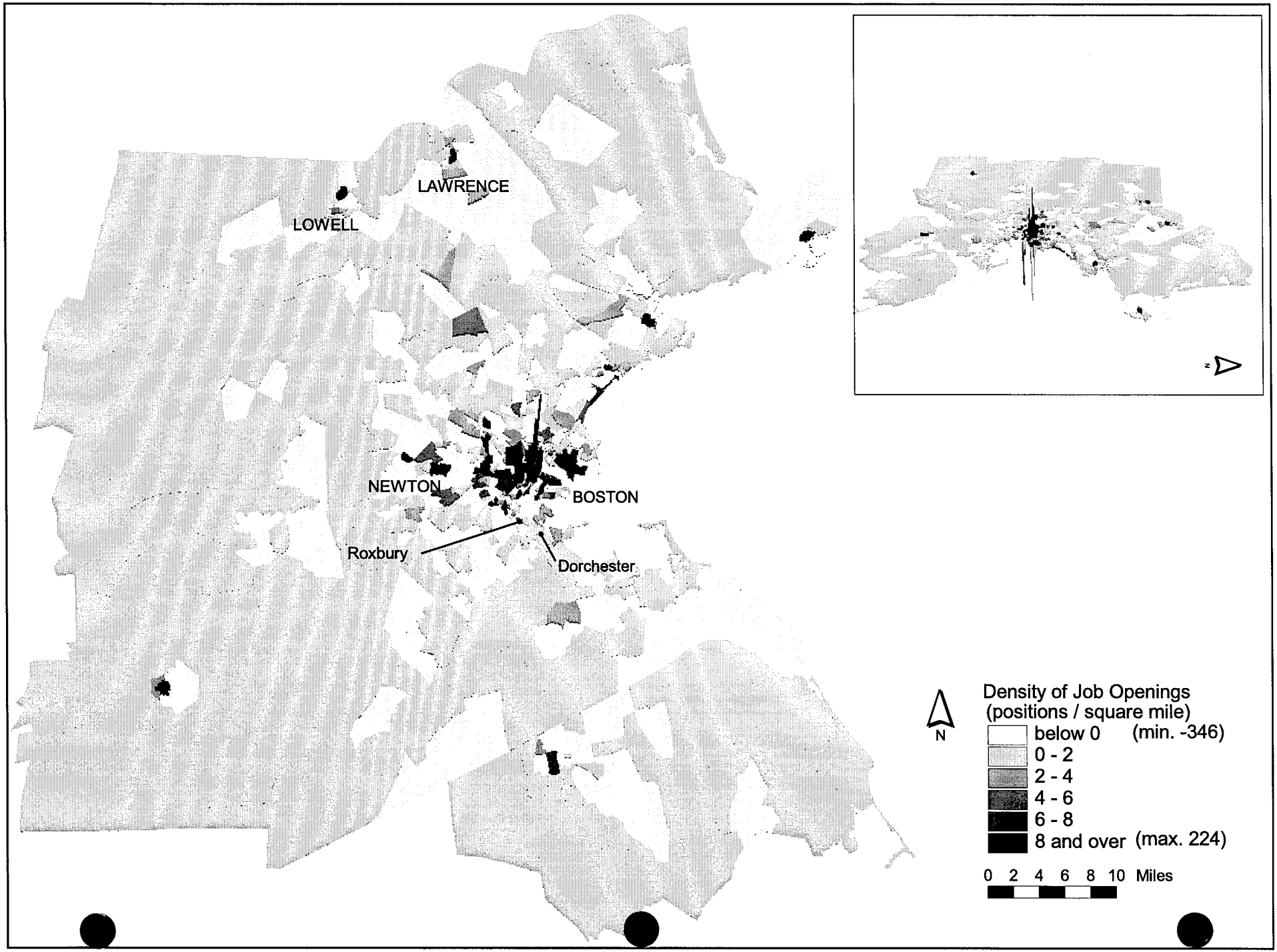
disadvantage in access to economic opportunities will be addressed later.

The spatial distribution of job openings suitable for less-educated job seekers is depicted in more detail in three maps, which are directly comparable because they use the same data classification/visual presentation scheme. Map 1 displays the density (height) and number (volume) of positions created by employment growth in each zone. Map 2, on the other hand, portrays the density and number of vacancies created by turnover in each zone. Obviously, new jobs were spatially more dispersed than pre-existing jobs. In fact, Map 1 shows that job growth was negative in a considerable percentage of zones located in the central city. Most of such zones are located in or near low-income neighborhoods. But Map 2 shows that densities of vacancies created by turnover were rather high in most central-city zones. Overall, as shown in Map 3, job openings were highly concentrated in the central city. The great majority of suburban zones had low densities of job openings. Only a small number of them showed moderate densities.

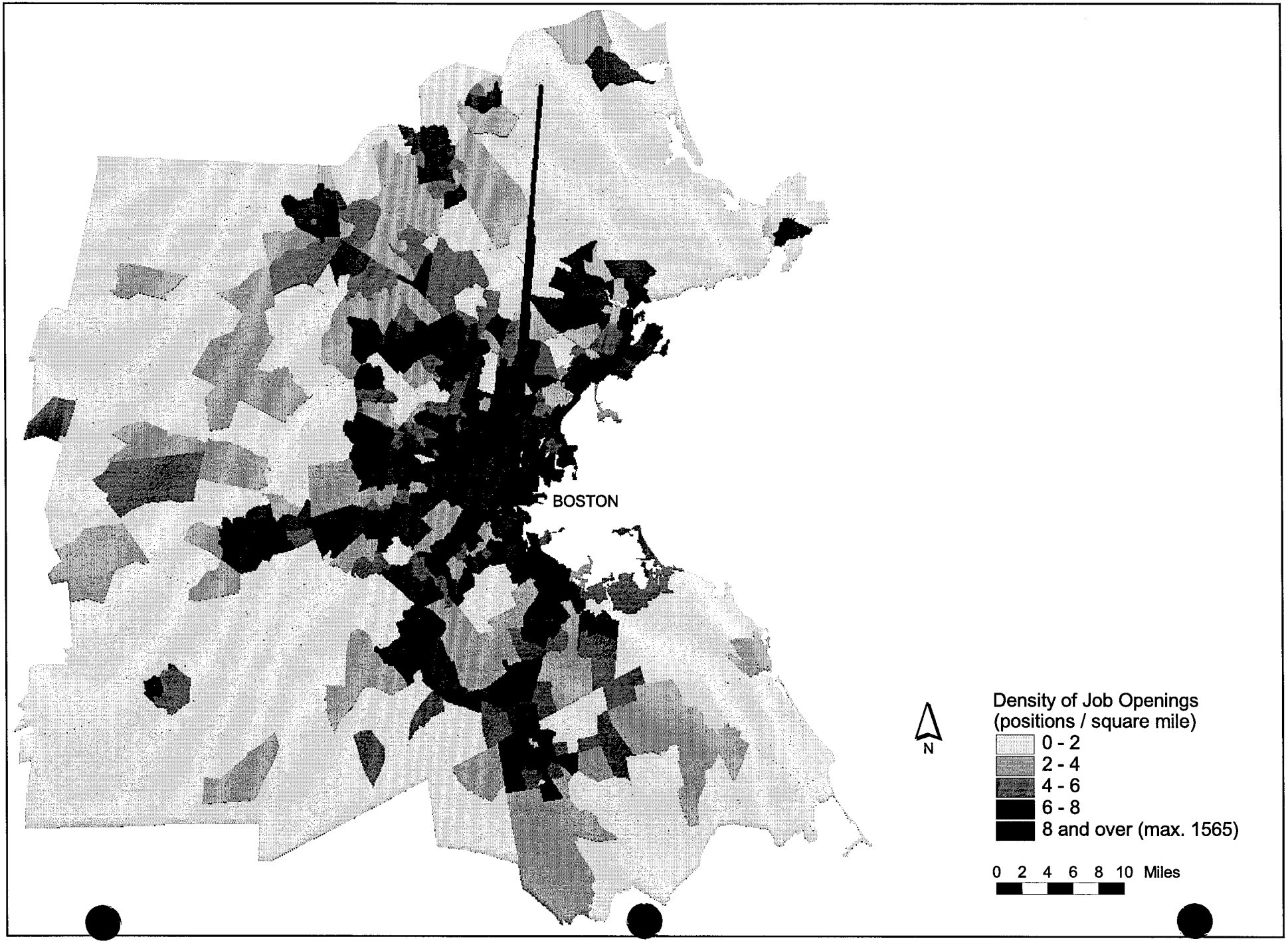
The spatial distribution of less-educated job seekers is displayed in Map 4. The figures shown in this map are calculated on the basis of the assumption that the occupational distribution of unemployed residents resembles the occupational distribution of employed residents. On the census day in 1990, there were an estimated 50,480 less-educated job seekers in the Boston Metropolitan Area.[8] Obviously, job seekers were highly concentrated in the central city. However, a number of neighborhoods in low-income far-suburban towns, especially the declining manufacturing towns of Lawrence and Lowell located near the northern boundary, also had very high densities of job seekers.

[8] When the census was taken in 1990, there were roughly 137,210 unemployed workers living in the 775 zones. It is estimated that approximately 50,480 of them would seek positions in sales, services, and labor-intensive occupations.

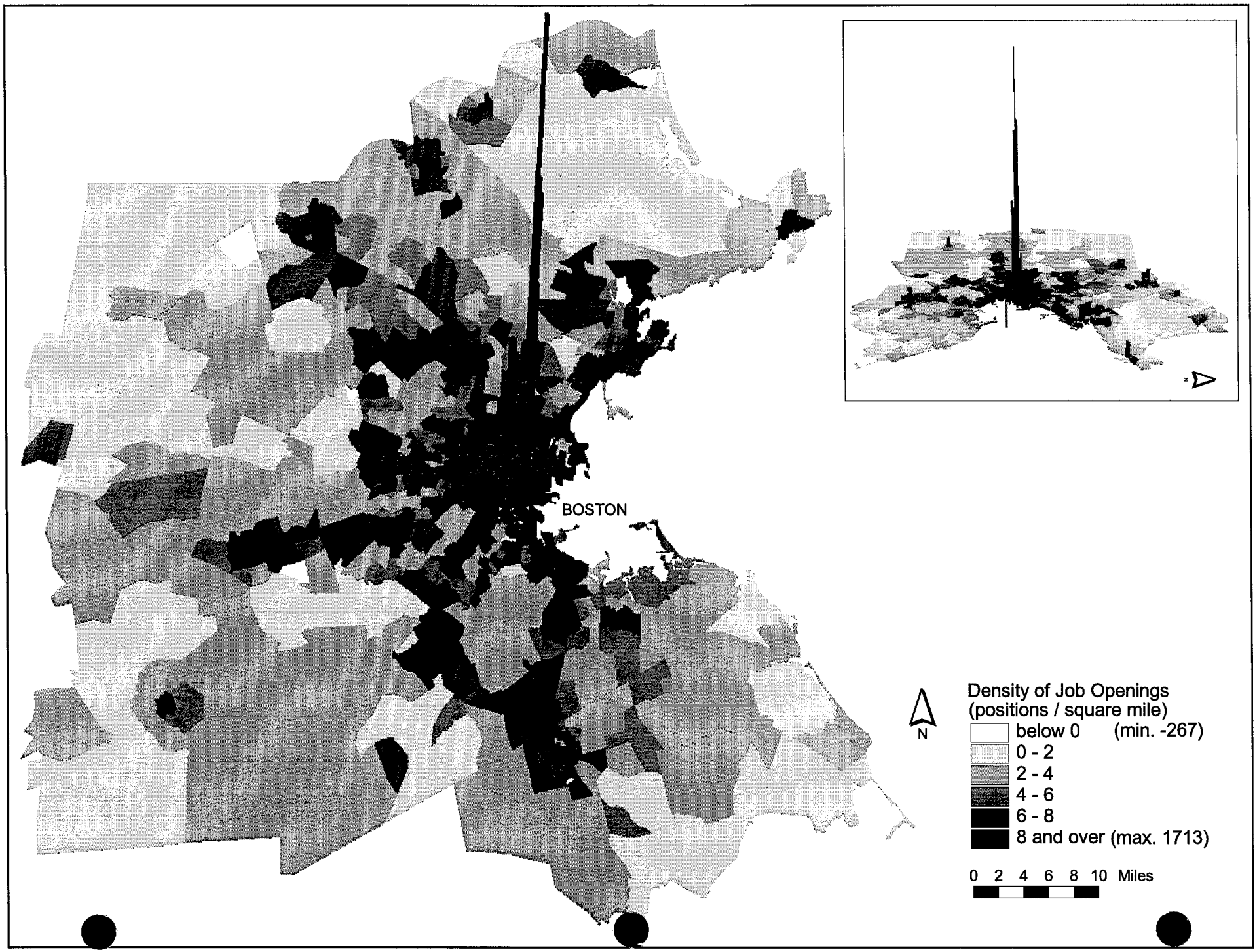
Map 1. Density of Job Openings due to Employment Change



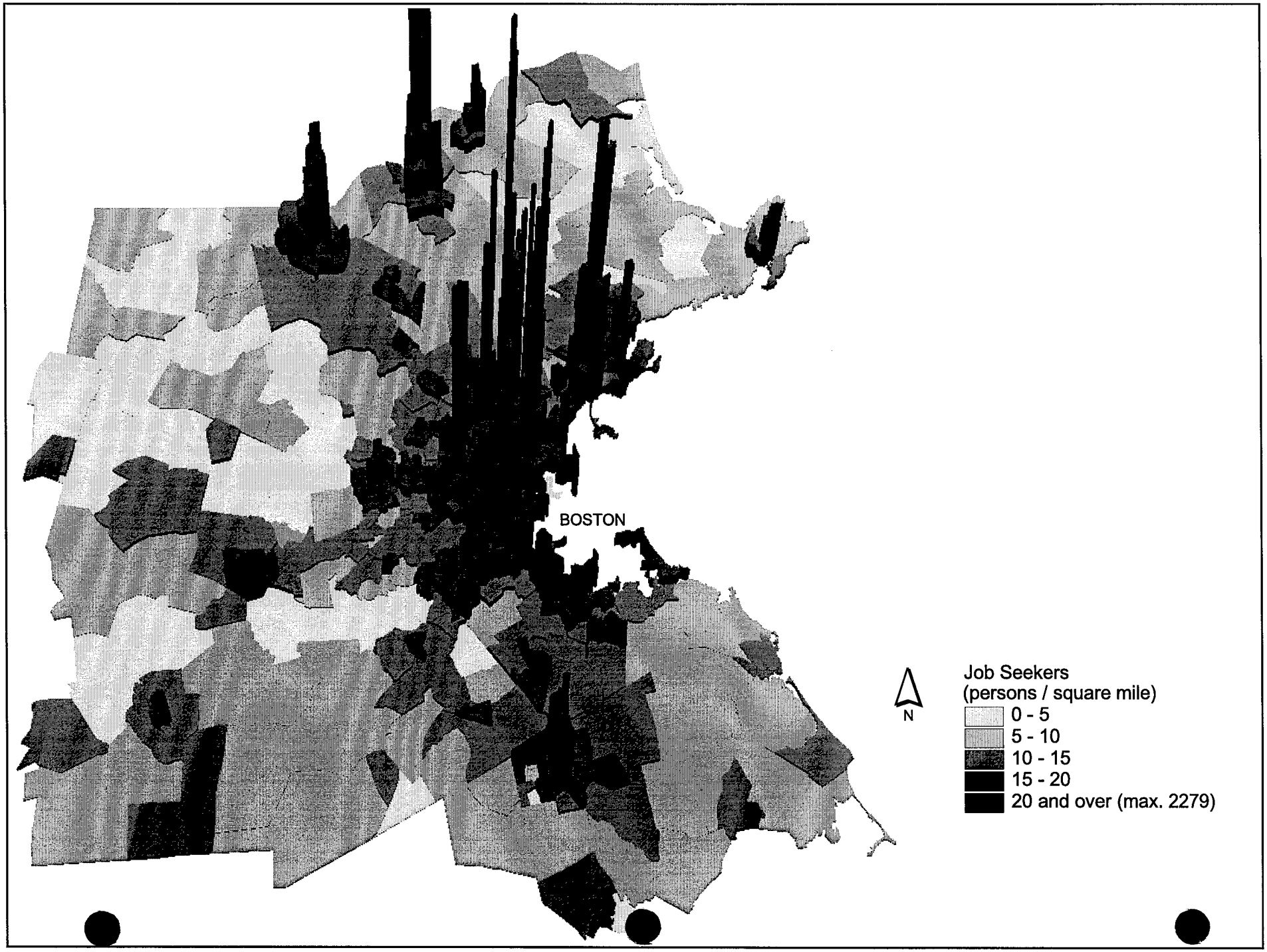
Map 2. Density of Job Openings due to Turnover



Map 3. Density of Job Openings in Total



Map 4. Density of Job Seekers



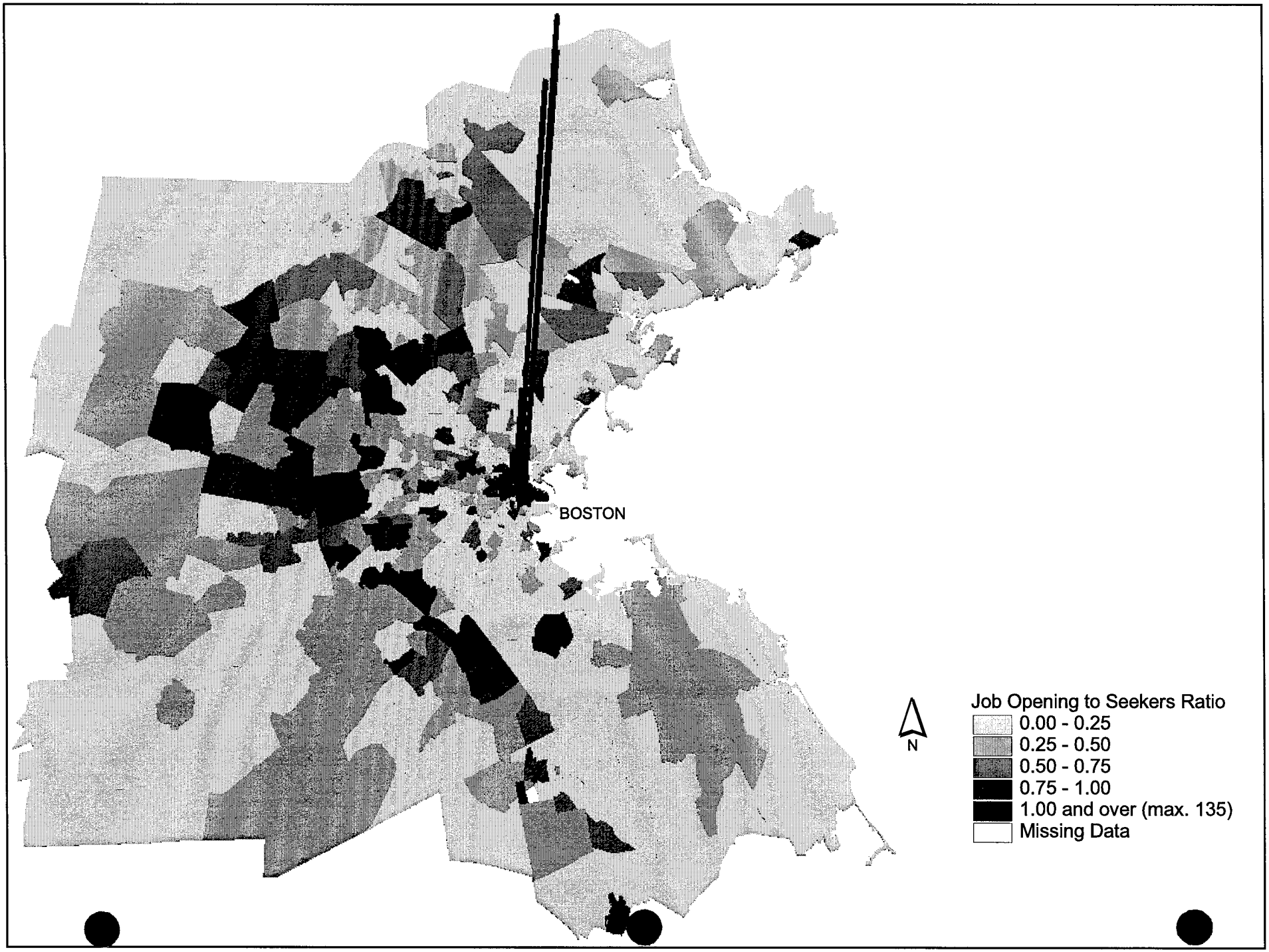
Map 5 shows the ratio of job openings to job seekers in each zone. For the metropolitan area as a whole there were estimated 10,690 positions in sales, services, and labor-intensive occupations and 50,480 seekers of such positions; therefore, the average ratio was roughly 0.2. Zones with a higher ratio were opportunity-rich; zones with a lower ratio were opportunity-poor. The map indicates clearly that the central business district (CBD) and a considerable percentage of suburban zones were among the opportunity-rich areas, whereas many central-city low-income neighborhoods and several poverty enclaves in far-suburban manufacturing towns were the most pronounced opportunity-poor areas. It is especially worth noting that the CBD, which is located not far from many low-income neighborhoods located in or near the central city, was extremely opportunity-rich. It is also worth noting that most of the opportunity-rich suburban zones are located not far from the central city.

Spatial Variations in Accessibility to Job Openings

It is clear that job seekers living in central-city low-income neighborhoods and suburban poverty enclaves do not find many local opportunities. But this does *not* necessarily mean that they had a low level of job accessibility. Accessibility depends not only on the number of opportunities located within their neighborhoods but also on the distance from employment centers (such as the CBD) and the travel mode and relative speed. For example, a job seeker living in an opportunity-poor central-city zone may have a relatively high level of job accessibility if the CBD is not far away. On the other hand, a job seeker living in an opportunity-rich suburban area may have a relatively low level of job accessibility if he or she does not own a car and does not have access to good transit service.

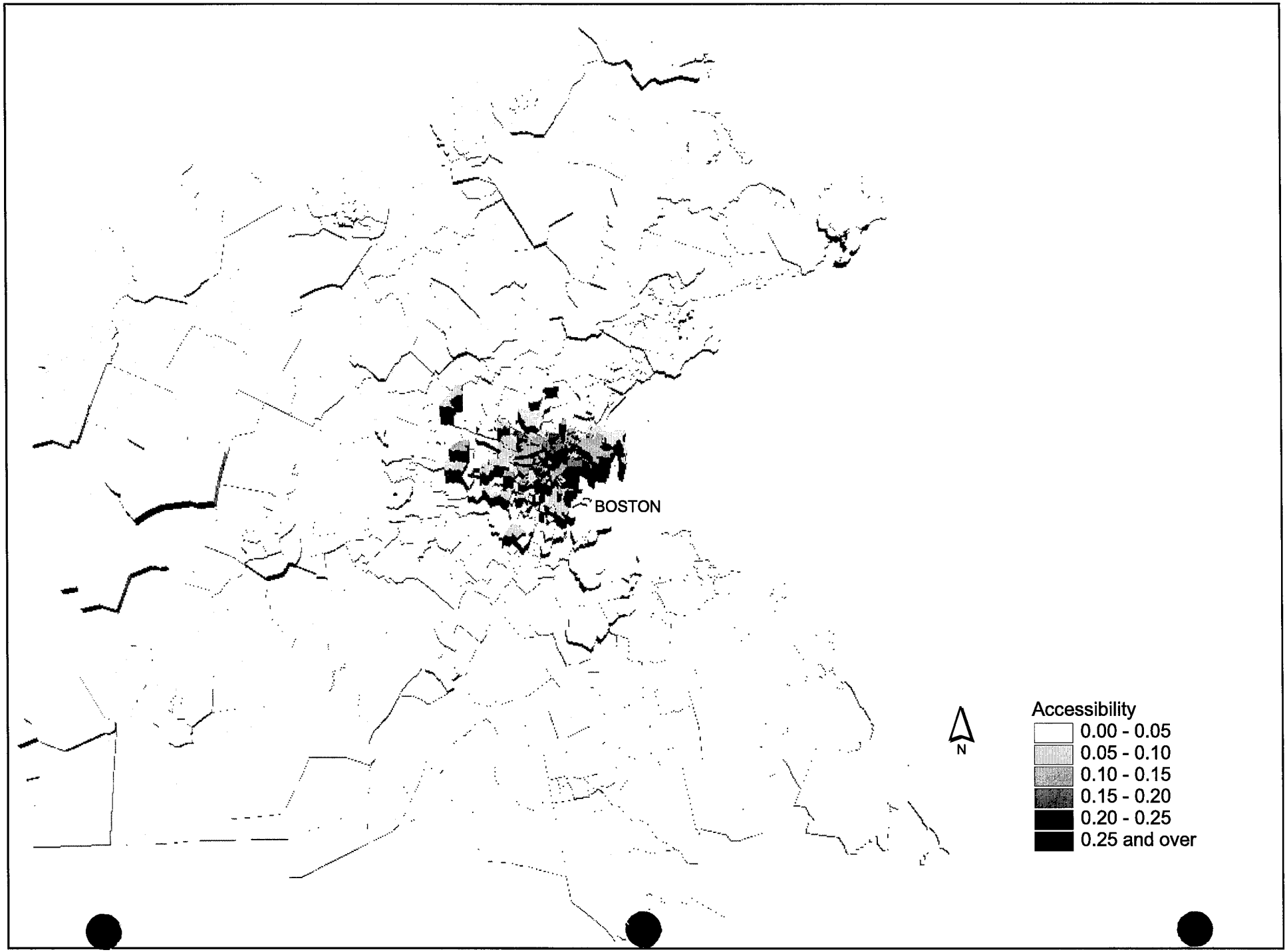
Accessibility to job openings for job seekers living in each zone and commuting by each mode is measured systematically using equation (4) and equation (5). The results are shown in Map 6 and Map 7, which display accessibility to job openings, respectively, for job seekers commuting by private auto and for job seekers commuting by public transit. Some summary statistics are reported in Table 3. All these results are obtained by

Map 5. Ratio of Job Openings to Job Seekers



Map 6. Automobile Commuters' Accessbility to Job Openings

Map 7. Transit Commuters' Accessbility to Job Openings



calculation based on the assumption that the threshold travel time is 30 minutes.

Table 3. Accessibility to Job Openings by Travel Mode
(Travel Threshold Time is assumed to be 30 Minutes)

Travel Mode	Average Score of Accessibility	Number of Accessibility-rich Zones
Automobile	0.31	542
Transit	0.03	2

Map 6 indicates that if seekers traveled by car and were willing to commute for up to 30 minutes, they would have a relatively high level of accessibility to job openings as long as they did not reside at the periphery of the metropolitan area. In fact, 542 out of the 775 zones were accessibility-rich for job seekers who traveled by car (i.e. they had accessibility scores higher than the expected value of 0.2). It is especially important to note that central-city low-income neighborhoods, in comparison with a great majority of peripheral and suburban locations, still had some advantage in access to job openings. This finding is consistent with what was reported in Shen (1998). However, the map also shows that there was a large cluster of zones in the wealthy west suburbs that had a high average level of accessibility to job openings.[9] These zones were the locations of many new firms, especially firms in the fast-growing high-tech industry. The location advantage of these zones is more pronounced when accessibility is measured based on job openings instead of employment levels.

Map 7 shows that if seekers were willing to commute for up to 30 minutes but were dependent on public transit, they would have a very low level of accessibility to job openings almost anywhere they lived. Only two zones, both located in the CBD, were accessibility-rich for job seekers who relied on public transit. The average accessibility score for transit-dependent seekers was merely 0.03. These results confirm another finding of Shen (1998), that is, travel mode, rather than residential location, is the

[9] Most of these zones are located in the towns of Newton, Waltham, and Wellesley.

predominant factor in determining accessibility in contemporary US metropolitan areas. The map also indicates that the central city, including most zones located in low-income neighborhoods, still showed a slightly higher average level of accessibility to job openings than did the majority of peripheral and suburban locations. In addition, it suggests that spatial variation in the level of accessibility for transit-dependent job seekers reflected the alignment of the transit network. Although some suburban employment centers had good transit service and therefore were among the better residential locations for job seekers who depended on public transportation, the majority of suburban zones were simply inappropriate as residential locations for people who did not have a car.

Sensitivity to Different Assumptions

Four alternative assumptions are tested and the results are compared with those we have just described. First, different turnover rates are used to estimate job openings. But even if the monthly turnover rate were 2 percent (i.e., the low end of the range) instead of 3 percent, employment growth would still be a relatively minor source of job openings in the Boston Metropolitan Area.

Second, job seekers are estimated based on the alternative assumption that all unemployed workers were willing to take positions in sales, services, and labor-intensive occupations. The resulting spatial distribution of less-educated job seekers, and subsequently spatial variations in accessibility to job openings, do not change appreciably.

Third, level of auto ownership in each zone is estimated with the alternative assumption that a fixed percentage of less-educated job seekers owned one or more motor vehicles regardless of their location. Assuming that the level of auto ownership among job seekers was 50 percent in every zone, the measurement of accessibility is repeated. The outcome is quite similar.

Finally, the alternative threshold travel times of 15 minutes and 45 minutes are used to generate accessibility scores. The results are quite sensitive to the specification of threshold travel time. With the shorter threshold of 15 minutes, there were many more local variations in accessibility to job openings. Most importantly, a high percentage of low-income zones in the central city had much lower accessibility because opportunity-rich locations—especially the CBD—were more than 15 minutes away. On the other hand, a considerable number of suburban zones, including many in the north-west suburbs, had higher accessibility because they tended to be opportunity-rich and were more than 15 minutes away from unemployed workers living in most of opportunity-poor zones. On the other hand, with the longer threshold of 45 minutes, the effects were the opposite.

The difference in the results obtained from using the different threshold travel times suggests that accessibility for job seekers living in central-city low-income neighborhoods is highly dependent on not only the travel mode, but also the distance to the CBD and the job-search and commuting behavior. While the average job seekers are probably willing to commute up to 30-45 minutes, a considerable percentage of them—especially women with young children—probably want to work near home, with a short commute (Hanson and Pratt, 1995). In the case of the Boston Metropolitan Area, given the spatial proximity between central-city low-income neighborhoods and the CBD, the average job seekers living in these neighborhoods may have some location advantage in access to job openings.[10] But for those who can only commute up to 15 minutes, living in these neighborhoods translates into location disadvantage in access to job openings. Therefore, this study has revealed more complexity in central cities' location characteristics than previously discussed.

[10] The largest low-income neighborhoods in Boston, Roxbury and Dochester, for example, are about 20-30 minutes away from the CBD by driving, and 30-50 minutes away from CBD by riding public transit, during peak hours.

Discussion

One may argue that given the booming economy of the 1990s, the importance of employment growth in creating openings is underestimated in this study. It is certainly true that a large number of jobs were created during the past several years, and that the numbers of estimated job openings due to growth would be greater if more recent employment data were available for the zones. But even if we doubled the pace of employment growth, turnover would still be the dominant source of job openings.

The more challenging issue concerns alternative definitions of less-educated workers and jobs suitable for them. Because of data limitation, less-educated job seekers and job openings suitable for them are both defined rather broadly in this study. If more disaggregated data were available, one would most likely find that the least-educated/lowest-income job seekers, for example welfare recipients, are relatively more concentrated in the central city than what is shown in Map 4. Similarly, one would also find certain kinds of opportunities, such as baby-sitting jobs, are more decentralized than what is shown in Map 3. Therefore, if the job market differentiates welfare recipients from the rest of less-educated job seekers, it may be the case that for welfare recipients, the central city is a relatively disadvantaged residential location in comparison with many suburban neighborhoods. However, in any case, the finding that accessibility differentials attributed to residential locations are small in comparison with accessibility differentials attributed to transportation modes remains valid.

V. CONCLUSION

This study has shown clearly that in the case of the Boston Metropolitan Area, most job openings come from turnover rather than employment growth. The estimation of the number of job openings on a typical day in 1990 indicates that turnover accounted for approximately 95 percent of all economic opportunities for unemployed workers and for an even higher percentage of the opportunities suitable for those with little formal education. Employment growth is a minor source of job openings.

Although a large portion of employment growth is in the suburbs, on a typical day the number of job openings created by growth is small. Furthermore, these opportunities are spatially dispersed over a very large territory. On the other hand, pre-existing employment—the primary source of job openings—is still highly concentrated in the central city. Consequently, job openings, including ones that require relatively little education, are still relatively concentrated in commercial and industrial areas of the central city.

Less-educated workers who seek jobs are also relatively concentrated in the central city—more specifically, in its low-income residential neighborhoods. On balance, low-income residential neighborhoods in the central city are mostly opportunity-poor, as there are generally more job seekers than job openings in such areas. However, these neighborhoods are located reasonably close to opportunity-rich commercial and industrial areas of the central city, including the CBD, which is extremely opportunity-rich. They are also not far from some opportunity-rich suburban locations.

For less-educated job seekers who are willing to spend a normal amount of time on commuting, residing in the central city of the Boston Metropolitan Area still means a small amount of location advantage in access to job openings. The 1990 zone-to-zone travel time data indicate that 30 minutes of travel by either car or subway would take residents of low-income neighborhoods in the central city to some opportunity-rich commercial and industrial areas located nearby. The analysis has shown that, for the average job seekers (i.e., those who are able to commute for up to 30 minutes), the central city as residential location offers somewhat higher job accessibility than do the majority of suburban and periphery areas. On the other hand, for those who can only work near home and therefore cannot access opportunities located outside the low-income neighborhoods, the opposite is true.

Most importantly, the analysis has demonstrated that accessibility differentials among locations within the metropolitan area are rather modest when compared to accessibility

differentials between travel modes. Measurement of accessibility to job openings in 1990 has shown that for job seekers who travel by car, most residential locations will allow them to have an accessibility level higher than the average. On the other hand, for job seekers who depend on public transit, the great majority of residential locations are associated with an accessibility level substantially lower than the average.

These findings have important methodological implications. First and foremost, in any study of spatial patterns of job openings and access in a US metropolitan area, employment growth should not be used as the sole empirical basis for identifying economic opportunities. In the case of the Boston Metropolitan Area, a study that neglects the turnover factor in effect overlooks 95 percent of the whole picture! Furthermore, the incomplete picture is biased, because spatial pattern of employment growth presents an overly optimistic view of economic opportunities in the suburbs and an overly pessimistic view of opportunities in the central city. To be sure, in comparison with the Boston case, some other metropolitan areas may have a relatively higher pace of employment growth and more intra-metropolitan employment relocations. However, given the high level of labor mobility in this country, it is unlikely to find any case where employment growth is the primary source of job openings.

Second, in measuring job seekers' accessibility to economic opportunities, those who can travel by automobile should be distinguished from those who depend on public transportation. A study that mixes these two groups will inevitably lead to a biased outcome, which understates the level of access for the former and overstates it for the latter. It is critical for urban researchers to remember that a high percentage of less-educated job seekers, and an even higher percentage of welfare recipients, do not own any automobile.

Third, in assessing spatial obstacles faced by job seekers, those who have a normal time constraint should be distinguished from those who have a more stringent time constraint. A study that does not make this distinction will underestimate the spatial disadvantage resulting from having a small time budget for commuting. It is important for researchers

to keep in mind that a very high percentage of the unemployed, especially adult welfare recipients, are single mothers who bear many domestic responsibilities, which may prevent them from commuting far from home.

The fourth and final methodological implication is that, in analyzing intra-metropolitan variations in accessibility to job openings, the data should be processed at an adequate level of spatial resolution to capture differences among central-city neighborhoods and among suburban locations. In the case of the Boston Metropolitan Area, although low-income residential neighborhoods in the central city are opportunity-poor, they are spatially proximate to some opportunity-rich areas, especially the CBD, and therefore still offer a small location advantage to those job seekers who are willing to commute beyond their neighborhoods. Whether or not this is also true in other metropolitan areas is unknown, and should be examined in future research. Careful examination using spatially disaggregated employment, demographic, and travel data is the only approach to finding it out.

The findings of this study also have major policy implications. One policy implication is that residential dispersal is unlikely to be an effective strategy for removing spatial barriers to low-income people's access to economic opportunities. To be sure, as Wolpert (1999) observes, central cities are both havens and traps for the neediest population groups, and the haven quality has been eroding relative to the trap. However, as far as access to job opportunities is concerned, central cities are probably still superior to many suburban locations. The Boston case study has shown that, contrary to the prevailing view, job seekers would most likely face similar—if not greater—spatial obstacles by relocating from the central city to the suburbs. Given the fact that turnover, rather than employment growth, is the primary source of job openings, there is no reason to expect a fundamentally different conclusion from other US metropolitan areas. Of course, this general conclusion may not apply to some special groups of job seekers. For example, central-city residents who are searching for positions in household services, which are relatively concentrated in wealthy suburban areas, may find some suburbs more desirable as residential locations. But for the majority of less-educated job seekers, residential

dispersal would not improve accessibility.

This is not to deny the importance of establishing a non-discriminatory suburban housing market. A non-discriminatory suburban housing market would allow a healthy residential mobility of low-income households, and enable them to optimize their residential location by choosing freely between the central city and the suburbs. For example, central-city residents who have found jobs in the suburbs can benefit from moving closer to employment location. Furthermore, there are a wide range of potential benefits of suburban housing, including school quality, safety, and opportunity for exposing to the main-stream cultural and social environments (Rosenbaum, 1995). However, the belief that the suburbs are generally better locations for less-educated job seekers to access jobs and suburban housing can effectively connect them to suitable opportunities is the result of misperception, which needs correction.

Another important policy implication is that great efforts need to be made to improve transportation mobility of job seekers who are currently dependent on public transit. These job seekers have a major comparative disadvantage in competing for economic opportunities. Because very few residential areas have enough location advantage to make up for their mobility disadvantage, the challenge is to devise innovative approaches to reducing the gap in transportation mobility. There is an emerging consensus among urban researchers that transportation policy must be directed toward low-income people who are unable to benefit from the mobility of automobile (Blumenberg and Ong, 1998; Ong, 1996; Shen, 1998; Wachs and Taylor, 1998). However, researchers have not reached an agreement on what actual transportation services and programs should be provided. This is an important question for future research.

Current welfare reform presents a great challenge to urban researchers, because we need to help policy makers identify various barrier and design strategies for removing these barriers. On the other hand, it also provides an opportunity for reexamining and, perhaps reshaping, important aspects of antipoverty policy. This study has shown that in order to help job seekers in general, and welfare recipients in particular, improve access to

economic opportunities in the contemporary US metropolitan area, we must now rethink strategies for removing spatial barriers. Increasingly, it is the capability to over come spatial separation, not the residential location, that is the primary determinant of an individual's position in the geography of opportunity (Shen, 1999).

REFERENCES

Anderson, P. and B. Meyer. 1994. The Extent and Consequences of Job Turnover. *Brookings Papers on Economic Activity—Microeconomics*, 177-248.

Blumenberg, E. and P. Ong. 1998. Job Accessibility and Welfare Usage: Evidence from Los Angeles. *The Journal of Policy Analysis and Management.*

Ellwood, D. T. 1986. The Spatial Mismatch Hypothesis: Are There Teenage Jobs Missing in the Ghetto? In *The Black Youth Employment Crisis*, edited by R. B. Freeman and H. J. Holzer. Chicago: University of Chicago Press.

Hanson, S. and G. Pratt. 1995. *Gender, Work and Space*. New York: Routledge.

Holzer, H. J. 1996. *What Employers Want? Job Prospects for Less-Educated Workers.* New York: Russell Sage Foundation.

Hughes, M. A. 1995. A Mobility Strategy for Improving Opportunity. *Housing Policy Debate* 6: 271-297.

Jencks, C. and S. E. Mayer. 1990. Residential Segregation, Job Proximity, and Black Job Opportunities. In *Inner-City Poverty in the United States*, edited by L. Lynn and M. McGreary. Washington, DC: National Academy Press.

Kain, J. F. 1992. The Spatial Mismatch Hypothesis: Three Decades Later. *Housing Policy*

Debate 3: 371-460.

Kasarda, J. 1995. Industrial Restructuring and Changing Location of Jobs. R. Farley, ed. *State of the Union: America in the 1990s, Volume I: Economic Trends*. New York: Russell Sage Foundation, 215-266.

Lacombe, A. 1997. *Welfare Reform and Access to Jobs in Boston*. Washington, D.C.: Bureau of Transportation Statistics, US Department of Transportation.

Laube, M., W. Lyons, and P. vanderWilden. 1997. *Transportation Planning for Access to Jobs*. Boston: Volpe National Transportation Systems Center.

Ong, P. 1996. Work and Car Ownership among Welfare Recipients. *Social Work Research* 20: 255-262.

Rich, M. J. and J. Coughlin. 1998. The Spatial Distribution of Economic Opportunities: Access and Accessibility Issues for Welfare in Metropolitan Atlanta. Paper presented at the 94th Annual Meeting of the Association of American Geographers.

Rosenbaum, J. E. 1995. Changing the Geography of Opportunity by Expanding Residential Choices: Lessons from the Gautreaux Program. *Housing Policy Debate* 6: 231-269.

Rosenbloom, S. and E. Burns. 1993. Gender Differences in Commuter Travel in Tucson: Implications for Travel Demand Management Programs. *Transportation Research Record* 1404: 82-90.

Shen, Q. 1999. Transportation, Telecommunications, and the Changing Geography of Opportunity. *Urban Geography* 20: 334-355.

Shen, Q. 1998. Location Characteristics of Inner-City Neighborhoods and Employment

Accessibility of Low-Wage Workers. *Environment and Planning B* 25: 345-365.

Taylor, B. and P. Ong. 1995. Spatial Mismatch or Automobile Mismatch? An Examination of Race, Residence and Commuting in US Metropolitan Areas. *Urban Studies* 32: 1453-1473.

Wachs, M. and B. Taylor. 1998. Can Transportation Strategies Help Meet the Welfare Challenge? *Journal of American Planning Association* 64: 15-19.

Weibull, J. W. 1976. An Axiomatic Approach to the Measurement of Accessibility. *Regional Science and Urban Economics* 6: 357-379.

Wilson, W. J. 1996. *When Work Disappears*. New York: Alfred A. Knopf.

Wolpert, J. 1999. Center Cities as Havens and Traps for Low-Income Communities: The Potential Impact of Advanced Information Technology. In *High Technology and Low-Income Communities*, edited by D. A. Schon, B. Sanyal, and W. J. Mitchell. Cambridge: MIT Press.