RESIDENTIAL DISTRIBUTION AS A KEY TO SUBURBAN INDUSTRIAL DEVELOPMENT

by

BERNARD J. FRIEDEN

B.A., Cornell University
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M.A., Pennsylvania State University
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Certified by . . . . . .
Thesis Supervisor

Accepted by . . . . . .
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ABSTRACT

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BERNARD J. FRIEDEN

Submitted to the Department of City and Regional Planning
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Master in City Planning

In order to determine the extent to which residential distribution influences the location of industry in metropolitan areas, this study explores theoretical and empirical relationships between the residential pattern of industrial workers and the location of industrial jobs. Evidence from various sources indicates that a number of conditions establish a spatial connection between places of residence and places of employment for industrial workers. Employers usually locate jobs close to existing concentrations of workers. Industrial workers generally will not move in order to be close to particular jobs. At a given time and place, most workers exhibit a high degree of uniformity in setting maximum limits for travel to work. In combination, the residential distribution of labor, together with prevailing commuting characteristics, determine the approximate number of workers potentially accessible to industries located at different points. Theoretically, the number of workers potentially accessible establishes places of high and low suitability for industry.

By means of an index devised for this study, communities in two metropolitan areas are rated according to their degree of labor accessibility. On the basis of existing industrial development, a critical minimum index value of labor accessibility necessary to support concentrated industrial development is determined empirically. Some communities with high labor accessibility are found to have relatively low concentrations of industry: labor accessibility is a necessary condition for industrial development but not a sufficient condition. During two periods of industrial growth surveyed, the contrasting experiences of communities with index values above and below the critical index value confirm that a minimum degree of labor accessibility is necessary to support major industrial development, and that this minimum degree may be determined by methods demonstrated in this study.

Thesis Supervisor: Lloyd Rodwin
Title: Associate Professor of Land Economics

LETTER OF TRANSMITTAL

Massachusetts Institute of Technology
Cambridge, Massachusetts

May 20, 1957

Professor Frederick J. Adams
Department of City and Regional Planning
Massachusetts Institute of Technology
Cambridge, Massachusetts

Dear Professor Adams:

In partial fulfillment of the requirements for the degree of Master in City Planning, I submit this thesis entitled "Residential Distribution as a Key to Suburban Industrial Development."

Sincerely yours,

Bernard J. Frieden

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Tables and Figures

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During the writing of this thesis, the entire faculty of the Department of City and Regional Planning furnished important assistance and advice. I am especially indebted for a number of useful suggestions to Professors John T. Howard and Kevin Lynch, and to Professor Lloyd Rodwin, who served as thesis adviser. In the early stages of this project, Professor Rodwin's criticisms helped particularly to define the purposes and scope of the study. I am grateful also to Professor Roland B. Greeley for his aid in gathering and interpreting information on the Boston and Hartford metropolitan areas.

Introduction

As our metropolitan areas continue to grow, housing and industry have both been developing at new locations in the suburbs. In the absence of large-scale metropolitan regional planning, no broad pattern has been imposed upon housing and industry to bring about a predetermined spatial relationship between them. Yet the considerations that guide individual industrialists and workers tend to bring about a configuration of their own based upon certain essential relationships between industry and its labor supply. This study is an exploration of the way in which residential distribution operates to influence the pattern of industrial development in metropolitan areas.

Whether the relationship between residential and industrial locations has an important influence on the industrial pattern within a metropolitan area has not yet been demonstrated. The hypotheses to be tested here constitute one conception of what the relationship is between residential distribution and industrial requirements, and how this relationship affects the location of new industry.

These hypotheses are:

1. In metropolitan areas, industries locate at sites accessible to an existing labor supply.

Whether a site is accessible to labor depends upon the residential distribution of labor and upon the distances workers are willing to travel to their jobs. Although both these factors change over time, this study considers the residential pattern and commuting characteristics at a single stage of metropolitan development, giving only minor

attention to questions of change. For purposes of this study, industries are not considered in separate categories, but all manufacturing industries are treated together. An examination of different kinds of manufacturing could conceivably demonstrate that several different development patterns arise according to type, but combining all kinds of manufacturing should make possible the delineation of a composite pattern, even if the aggregate is not as precise as its component parts would be.

2. Workers do not generally change residences in order to be near their jobs. When they change residences for other reasons, they do not choose sites primarily to be near their jobs.

This hypothesis is presented as a general statement covering most manufacturing workers. Workers in certain specialized occupations may tend to change residences in order to be near desirable jobs that are beyond commuting ranges, but for most workers job mobility is greater than residential mobility. An examination of workers in different occupations could clarify occupational differences, but this study combines all manufacturing workers in a search for the composite tendency.

3. Because industries locate to be accessible to labor, and because labor does not change its residential pattern to accommodate job locations, the residential distribution of labor constitutes an independent variable and the location of industry a dependent variable. The residential distribution of labor at any given time, together with commuting characteristics at this time, determine zones of high and low

labor accessibility. These zones are areas of high and low suitability for industry in terms of labor accessibility.

4. Zones of high and low suitability for industry in terms of labor accessibility may be determined for metropolitan areas at any given time.

For this determination, the residential distribution of industrial workers and their commuting characteristics must be known. Commuting characteristics reflect the times and distances workers are willing to travel, and the means of transportation available. In this study, commuting characteristics are generalized for all industrial workers without reference to occupational categories.

5. In zones of low suitability for industry drawn on the basis of labor accessibility, concentrations of industry will not develop unless the residential distribution of workers or their commuting characteristics change the degree of labor accessibility.

Several different approaches are used to test these hypotheses:

1. Evidence on how industry chooses sites is derived from surveys of the factors that motivate location decisions, and from information on the procedures that businessmen use in determining plant locations.

2. Evidence on how workers choose residences and why they move comes from a number of motivation studies based upon interview procedures. Other surveys indicate where workers choose residences in relation to their job locations, the extent to which workers adapt their residential locations to a change in place of work, and the modifying influence that

available opportunities exert upon worker attitudes and preferences.

3. A method is demonstrated for determining zones with different degrees of labor accessibility in metropolitan areas. Two metropolitan areas to be examined furnish illustrations of how the minimum degree of labor accessibility required for concentrated industrial development may be determined.

4. In the two sample metropolitan areas, zones above and below the critical degree of labor accessibility are identified.

5. Industrial development experiences in zones above and below the critical degree of labor accessibility are compared for the two metropolitan areas selected.

The investigations made in this study support the following conclusions about the hypotheses that are tested:

1. Businessmen generally choose industrial sites accessible to an existing labor supply. They do not normally locate factories beyond commuting range of an existing labor force on the assumption that workers will move to new homes in the vicinity of their jobs.

2. Most workers do not move in order to be near their jobs. When they move for other reasons, they choose new residences more on the basis of space facilities, costs, and outside appearance than on the basis of nearness to work. A number of surveys indicate that most industrial workers are more mobile in regard to jobs, industries, and occupations than they are in regard to residences.

In general, workers move closer to their jobs only when two

conditions are fulfilled: they are predisposed to move for reasons not related to commuting, and housing that meets their needs is available closer to their jobs than their previous homes were.

3. The location and nature of available opportunities for work and residence modify workers' commuting preferences, but the majority of workers nevertheless exhibit a high degree of uniformity in setting maximum limits for travel to work. Almost all surveys of distances travelled to work have found that at least 90% of industrial workers live within 20 miles of their jobs. Because of the uniformities in workers' commuting preference areas, the residential distribution of workers at any given time, plus their commuting characteristics at this time, establish zones with varying degrees of labor accessibility for industry.

Within limits imposed by the nature of available data, degrees of labor accessibility may be determined by means of an index measuring the relative numbers of workers living within normal commuting distances of any place for which the measure is taken. This index weights the numbers of workers residing in various distance categories according to the proportion of workers that have characteristically been found to live at these distances from their jobs.

4. The minimum degree of labor accessibility found in places with existing concentrations of industry has been used to establish an approximate critical minimum index value of labor accessibility necessary to support concentrated industrial development. In the metropolitan areas surveyed, only a small number of outlying communities had index values below this critical minimum at the time data was gathered (1947-

1950). Whether this pattern is typical of metropolitan areas, or whether other metropolitan areas have a greater proportion of land below the critical minimum degree of labor accessibility, cannot be determined without further surveys.

5. Index values of labor accessibility correlate only slightly with the extent of industrial development in each community. A strong correlation of this nature cannot logically be expected, however, since labor accessibility alone does not assure industrial development. Other conditions must also be satisfied before industries will locate in a community: labor accessibility is a necessary condition but not a sufficient condition for industrial concentration.

Limited evidence indicates that during periods of industrial growth, those communities that obtain the greatest number of industrial jobs have labor accessibility index values above the critical minimum. Communities that have index values below the minimum generally obtain only a small number of new industrial jobs. The only communities that have developed from low to high manufacturing densities during growth periods surveyed have had index values above the critical minimum. The investigations of industrial growth are preliminary in scope, but they suggest that the index of labor accessibility as constructed in this study does measure the desirability of different places for industrial development in terms of labor accessibility, and that places with low index ratings can support only limited industrial growth.

The concepts and techniques developed in this study have obvious

applicability in metropolitan land use planning, as well as in further investigations of accessibility. In metropolitan planning, the methods used here can provide a way to gauge the industrial implications of different residential patterns. They can also help identify areas of maximum and minimum suitability for industrial development. In addition, similar techniques can measure and evaluate accessibility relationships between the residential pattern and such other activities as shopping, non-manufacturing employment, and community facilities. In this way, the techniques used in this study can help fill in the total picture of internal metropolitan organization.

Chapter One

The Selection of Industrial Sites

The process of selecting industrial sites demonstrates the extent to which industries choose locations accessible to an existing labor supply. Choosing a location for industry consists of two distinct steps: selecting the region and finding a site within the region. Regional differences, with their corresponding cost differentials, result from such locational characteristics as nearness to raw materials, supplies of cheap power or labor, advantages in transportation, and nearness to market. After the region has been selected, however, other considerations determine the final factory location. In this second stage, the choice will depend upon such factors as land cost, availability of utilities, connections to highways and railroads, topography, and local attitudes toward industry. At this second stage, labor accessibility requirements must also be satisfied.

Although industrial location is logically a two-step process, businessmen may not make their decisions on a logical basis. Several studies covering a large number of plant locations have shown, however, that usually separate decisions determine the general region and the specific site. McLaughlin and Robock, in their study of new industry in the South, conclude that the businessman "almost invariably follows the practice of selecting a location in two steps," each with its own requirements.[1] The

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[1]Glenn E. McLaughlin and Stefan Robock, Why Industry Moves South (Kingsport, Tenn., 1949), p. 25.

National Industrial Conference Board, reporting on procedures for locating new plants, divides the steps that most firms use into somewhat finer categories: selecting the general area, selecting the community within that area, and choosing a site within that community.[1] Further confirmation appears in the findings of a survey that the Federal Reserve Bank of Boston sponsored to investigate locational factors affecting new manufacturing plants in New England. This survey of 106 new establishments has found that "quite different location factors were dominant in the two separate phases of the location problem," the regional decision and the community decision.[2]

When a firm decides upon a particular metropolitan area as the general region within which to locate a new plant, it does so upon the basis of regional factors. Having made this first decision, the firm leaves aside the reasons that induced this choice of region, and finds a site on the basis of other criteria. Thus, within a metropolitan area, the spatial distribution of industry does not generally reflect the factors that are responsible for the location of manufacturing in that region. Chauncy D. Harris has used an adapted population potential technique to demonstrate the importance of nearness to the market as a factor controlling industrial location.[3] Yet if two separate stages deter-

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[1]National Industrial Conference Board, Inc., Studies in Business Policy, No. 61, "Techniques of Plant Location" (New York, 1953), p. 4.

[2]George H. Ellis, "Why New Manufacturing Establishments Located in New England: August 1945 to June 1948," Federal Reserve Bank of Boston Monthly Review, XXXI (April 1949), 8.

[3]Chauncy D. Harris, "The Market as a Factor in the Localization of Industry in the United States," Annals of the Association of American Geographers, XLIV (December 1954), 315-348.

mine location, once a manufacturer has chosen some metropolitan area because of its strategic relationship to his market, he no longer pushes as close to the market as possible. Rather than locate in the heart of the city for maximum nearness to market, he will guide his choice of a site by other considerations.

A significant change of scale interposes between the choice of a region and the choice of a site. On the regional scale, distances to the market are considerable, and Harris' measures of market potential express important locational advantages. The site decision, however, depends on a metropolitan scale, where differences in market potential become negligible because of the small distances involved. Transportation costs from the factory to the market can vary greatly from region to region because of the long distances involved and because of the number of finished units to be shipped to markets of different sizes. But after the area of maximum transportation advantage to market has been selected, a shift of five or ten miles will make little difference in transportation costs. Terminal and handling costs would remain the same, and a slight extension of a trip that would be necessary in any case is less significant to the total cost picture than are other factors connected with metropolitan-scale location.

A similar argument could be made for the change of scale from regional to metropolitan when industries choose regions on the basis of low power or labor costs, rather than because of nearness to market. Extractive industries, however, are an exception. Oil wells must be located at the source of oil. When the source happens to be in a metropolitan

area, as in the vicinity of Los Angeles, location of the oil deposit is the primary consideration. Since extractive industries are rare in metropolitan areas, the general tendency remains for industry to choose metropolitan sites according to different criteria than it uses for choosing regions.

The criteria used for choosing sites are indicated partly in some of the surveys that have distinguished the two stages of industrial location: real estate considerations, community facilities, and engineering characteristics of the land, among others. But one factor that creates a pattern out of the many individual sites chosen is accessibility to a sufficient pool of labor. This factor is a necessary condition for site location, but by itself it is not a sufficient condition. Because it is a necessary condition, areas of adequate accessibility to labor constitute a zone within which industry may locate. Beyond this zone, even if all other conditions are fulfilled, industries cannot locate successfully in large numbers. Some plants with small working forces may nevertheless succeed outside normal areas of accessibility. Plants with large working forces could conceivably offer special inducements to draw workers beyond the normal commuting limits. Businessmen who consider the problem of site location analytically, however, are not likely to attempt operations in areas of low accessibility to labor.

That businessmen do choose sites with a view to labor accessibility is confirmed by various studies. The Boston Federal Reserve Bank survey of new manufacturing plants in New England discovered that in the choice of specific communities, two considerations were dominant: availability

of a suitable building and availability of labor supply. Labor supply was cited by 25% of all firms, and was second in frequency of mention to availability of a suitable building.[1] McLaughlin and Robock found that, aside from factories that have located in the South for savings in labor costs, where

> materials or markets have been the primary reason for new industry developing in the South, labor has sometimes played an important, though secondary role by helping to determine the specific location within a satisfactory area.[2]

In a manual on factory location, Leonard C. Yaseen, an industrial consultant, advises businessmen that the maximum labor market accessible to any proposed site will be contained within a 30-mile radius.[3] A location study described in the Harvard Business Review includes an examination of the labor force within a 25-mile radius of the proposed site.[4]

According to a planning study conducted by the University of Pennsylvania Institute for Urban Studies, the availability of housing for a labor force partly determined certain industrial locations on Long Island. The presence of Levittown, Long Island, this report maintains, "was at least in part responsible for attracting several aircraft manufacturers to Long Island. Many of their workers moved into the Long Island Levittown."[5]

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[1]Ellis, p. 8.

[2]McLaughlin and Robock, pp. 71-72.

[3]Leonard C. Yaseen, Plant Location (Roslyn, N.Y., 1952), p. 111.

[4]Frank F. Gilmore, "Thinking Ahead: Plant Location," Harvard Business Review, XXXIX (March 1951), 18.

[5]University of Pennsylvania Institute for Urban Studies, Accelerated Urban Growth in a Metropolitan Fringe Area (1954), I, 59.

Here, then, is direct evidence that many industrial sites are selected partly on the basis of accessibility to labor force. Numerous planners have recognized that industrial sites should be chosen in areas accessible to a sufficient labor pool,[1] but the insights of planners are not always reflected in the decisions of businessmen. On the question of site location, however, businessmen seem to be aware of their labor supply needs. The pattern of industrial development in metropolitan areas, therefore, may logically be expected to show the influence of these needs.

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[1]See, for example, American Society of Planning Officials Planning Advisory Service, Information Report No. 26, The Journey to Work: Relation Between Employment and Residence (Chicago, 1951); and John T. Howard, "The Express Highway: Its Industrial Development Potential," Association of State Planning and Development Agencies Proceedings (Chicago, 1953), pp. 94-99.

Chapter Two

How Workers Relate Residence and Job Locations:

I Mobility of Residence in Relation to Job Location

If convenient commuting times set a limit on the distance workers will travel to their jobs, then the degree to which residences are mobile in relation to job location will largely determine whether residences fix the metropolitan industrial pattern, or whether industrial sites fix the residential pattern. Thus if residences are completely immobile, a new factory must find a site close enough to the homes of all potential workers to allow commuting without any shifting of residences: in this case, if all other factors are equal, residential distribution of industrial workers controls the industrial pattern. Or if residences are completely mobile, a new factory may locate anywhere and workers will move close enough for commuting: in this case, industrial locations control the residential pattern of industrial workers. In actuality, residences are at neither pole, but most evidence suggests that they are much closer to complete immobility than to perfect mobility in relation to job location. To the extent that residences approach immobility with regard to job location, the hypothesis that residential distribution of industrial workers establishes an outer limit for industrial development will find confirmation.

Much interesting research has taken up the question of whether workers tend to move close to their jobs. Coleman Woodbury has suggested that they do, and he has sensed implications for the metropolitan pattern:

> Although we do not know much about the journey to work of urban dwellers, a fair amount of evidence points to the probability that industrial workers, as distinguished from people employed in central business districts, sooner or later seek housing fairly close to their places of employment. Thus industrial location, at least that in sizable districts, may be a major force in determining certain kinds of residential land use.[1]

J. Douglass Carroll has maintained the related point of view that industrial employees tend to minimize distances between home and work, but unlike Woodbury he does not limit the means of adjustment to changes in residence. In the main argument of his doctoral dissertation, he holds that the desire to minimize distance from home to work operates in the selection of both homes and work places. At several points in the discussion, however, he leans more strongly toward the view that workers will adjust their residences rapidly to be near their jobs: "The tendency to minimize work-travel may be expected to foster rapid and intense settlement in the environs of centers of employment."[2] In the more recent Detroit Metropolitan Area Traffic Study, of which Carroll was director, this view appears again: "some period of adjustment is required for plants established at new locations during which time employee residences are adjusted to the place of work."[3]

Elsewhere in planning literature, related viewpoints appear. In

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[1] Coleman Woodbury with the assistance of Frank Cliffe, "Industrial Location and Urban Redevelopment," in The Future of Cities and Urban Redevelopment, ed. Coleman Woodbury (Chicago, 1953), p. 110.

[2] J. Douglass Carroll, Jr., "Home-Work Relationships of Industrial Employees," unpublished dissertation (Harvard, 1950), p. 172.

[3] Report on the Detroit Metropolitan Area Traffic Study, Part I: Data Summary and Interpretation (1955), p. 95.

the Adams, Howard and Greeley planning study of the Farmington River Valley in Connecticut, Detroit findings are mentioned to support the position that "even in a restricted housing market people tend to locate as close to their place of work as possible." Industry tends to choose sites close to labor, according to this report, and workers tend to choose homes near their jobs: "The industry that moves completely away from an established pool of skilled labor is as unusual as the worker who moves to the other side of town from his job."[1] In reality, the two situations envisioned here are not equally unlikely. Industry, is very unlikely to move away from a labor pool, but many studies indicate that workers are quite likely to move to the other side of town from their jobs if they like the housing there.

Little confirmation for the positions that Woodbury and Carroll hold can be found in studies of worker motivation or in public opinion samplings. The empirical evidence that supports their position consists chiefly of information on distances between home and work collected in various surveys that stop short of questioning workers on reasons for their choices, and that fail to describe the total opportunities for homes and jobs from which workers had to choose.[2] Consequently, the tendency to minimize travel from home to work can at best be inferred from this information, but the same information lends itself also to

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[1]Adams, Howard and Greeley, Regional Planning Study: Farmington River Valley Region, 1955-1957, p. 107.

[2]This evidence is summarized in J.D. Carroll, Jr., "Some Aspects of Home-work Relationships of Industrial Workers," Land Economics, XXV (November 1949), 418.

other interpretations. In the light of a more comprehensive hypothesis, which will be applied to some of the same data in succeeding sections of this study, other inferences appear more reasonable.

Among motivation studies, only one lends any support to the contention that workers tend to move closer to their jobs. This is a wartime survey of 2500 homes in urban Scotland. In response to a question on the importance of having the place of work near home, 48% of husbands interviewed considered it very important, and 14% somewhat important.[1] Several objections, however, cast doubt upon the applicability of this survey. First, subjects were not asked whether they would move to be closer to work. Second, commuting characteristics in Scotland are so different from those in the United States that Scottish opinion may not be at all pertinent to circumstances in this country.

A number of well executed studies indicate that workers have little tendency to move close to their jobs. One of the best is a recent survey of over 900 households in four areas of Philadelphia, Peter H. Rossi's Why Families Move. In an effort to determine sources of dissatisfaction with residences, Rossi set up a series of questions to find out which aspects of housing brought complaints, and which aspects of housing were regarded with indifference. Of the total sampling, which included a variety of locations in regard to work places, only 8% of households complained about travel to work. Ranked according to this percentage of complaints, travel to work was only twelfth in importance among

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[1]Dennis Chapman, "'Convenience' -- The Measurement of a Desirable Quality in Town Planning," Human Relations, III, No. 1 (1950), 80.

fourteen factors considered. The proportion of households that were indifferent was 10%; on this basis, travel to work was fourth highest of the fourteen factors in the indifference ranking.[1]

Interviewers questioned people directly about their inclination to move elsewhere. Rossi then devised several complaint indices to match against mobility inclinations, in an effort to learn which complaints precipitate moving. His index derived from complaints about neighborhood location, of which complaints about travel to work constituted a major component, showed "a very weak and irregular relationship to mobility potential."[2] In view of commonly held opinions that the journey to work plays a major part in determining mobility, Rossi finds his results surprising. His explanation is that these opinions may have been justified formerly, when mass transportation was poorly developed and the cost of travel to work was high in relation to income. A well-developed mass transportation network in Philadelphia and widespread automobile ownership may well account for the negligible influence of commuting dissatisfaction upon inclination to move.

The positive findings in this work are that space complaints, which arise chiefly when family size changes, are the most important single reason for moving. When a family decides to move, however, transportation to work becomes one of the significant factors influencing the choice of a new residence. Among the sampling of families that moved during the survey, 42% rated the dwelling that they chose as better

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[1] Peter H. Rossi, Why Families Move (Glencoe, Ill., 1955), p. 82.
[2] Rossi, p. 85.

than others considered in regard to transportation to work. On the basis of this rating system, transportation to work was third in importance, below costs and outside appearance.[1]

Conclusions suggested by the Rossi book are that few workers change their residences in order to be near their jobs, but that when people change residences for other reasons, the journey to work is one factor influencing their final choice. Job locations, therefore, do not determine the residential pattern of workers, but because workers do move at various times, the residential distribution of workers may adjust very slowly to the location of work places. Under these circumstances, industry would be poorly advised to choose sites on the assumption that employees will change residences in order to adjust their journeys to work.

Another recent survey has studied industrial workers in four areas of upper New York state, with special attention given to commuters who traveled more than twenty miles to work. These long-distance commuters showed little tendency to move closer to work. Questions about the length of time workers had spent in their present jobs and homes indicated certain mobility characteristics:

> Whereas only one-fourth of the respondents had been working in the same place for as long as five years, 40-50 per cent had been living in the same house for five or more years. Job mobility was greater in this group of long-distance commuters than residence mobility.[2]

Interviewers asked the long-distance commuters whether they would

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[1]Rossi, p. 164.

[2]Leonard P. Adams and Thomas W. Mackesey, Commuting Patterns of Industrial Workers (1955), p. 62.

move closer to work if they could get good housing at a good price. More than half the subjects in all areas said they would not; in some places, 80% said they would not. Altogether, 753 of a total sampling of 1303 said that they would not move. The reasons they gave most frequently were satisfaction with home and neighborhood, ownership of home, and preference for small town or country life to life in an industrial area.[1]

A sizable number of long-distance commuters, 343, had moved since they started work on their current jobs. One hundred had moved into the 20-mile-plus zone from places nearer to their jobs. Of the other 243 who stayed within the 20-mile-plus zone, 69 moved further away from their jobs, 93 stayed at about the same distance, and 81 moved closer. Adams and Mackesey conclude: "These data are admittedly difficult to interpret without more information on such matters as housing, but they certainly do not suggest a strong tendency of workers to lessen the distance between home and job."[2]

Generalizations based upon a study of long-distance commuters will of course exhibit a bias because the respondents are precisely the people who choose to keep job and residence far apart. In the different areas that Adams and Mackesey surveyed, the percentage of workers who lived more than twenty miles from their jobs ranged from a low of 1.9% to a high of 11.8%. Although the bias is obvious, a point in favor of studying long-distance commuters is that they have encountered the extreme inconveniences accompanying a long trip to work. Knowing what

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[1]Adams and Mackesey, p. 63.
[2]Adams and Mackesey, pp. 63-64.

these inconveniences are, the majority nevertheless have no inclination to adjust the length of this trip by moving closer to work.

Adams and Mackesey's conclusions do not rest entirely upon the survey of long-distance commuters. Referring to prior work in this general field, they comment:

> Postwar studies serve to emphasize ... that in peacetime, as probably in wartime, commuting distances and time spent getting to work tend to be more variable than changes in place of residence. The evidence indicates a greater willingness to change jobs and travel farther than to move from one residence to another.[1]

Of the studies that they cite, two are particularly important. Both are concerned primarily with the economic concept of a labor market, but both have contributed striking confirmations of the hypothesis that residential mobility is less than job mobility.

The first of these studies draws upon interviews conducted with manual workers (skilled and unskilled) in an unidentified New England city, which is apparently New Haven. On the somewhat extreme question of large-scale geographic mobility -- from New Haven to another area -- the sampling interviewed had little potential for changing their places of residence. Of 450 respondents, 45% said that they would not move to another area under any circumstances; 12% said they would for a moderate pay increase (25% or less); 30% would be willing for a large pay increase (25 to 100%). Among a group of 50 unemployed workers, potential mobility was somewhat greater, but largely for single people: only one-fifth of workers who were members of families said they would go to another area

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[1]Adams and Mackesey, p. 43.

to get a job, while two-thirds of the unattached workers were willing.[1]

Moving to another area is an extreme test of residential mobility. The interview questions on this point did not define the distance that might be involved in such a move, but the wording suggests more than a shift to some nearby suburb. Since respondents probably assumed that moving to another area would mean breaking all normal ties with New Haven, their lack of potential mobility is not surprising. Reynolds has found, however, that even within the metropolitan area residential mobility is low:

> The fact that people like to live near their work would not constitute a barrier to interplant mobility if residential preferences were slight. In this event a worker would shop for work throughout the city and, having located a job, move to a new residence near the plant. This is not, however, the predominant pattern of behavior. Residential preferences are strong, particularly in the case of home owners, and place of work tends to be adapted to place of residence rather than vice versa.[2]

One example of this adaptation occurs when workers lose their jobs. Because plants in the same industry do not generally congregate in the same area, unemployed workers must usually choose between remaining in the same neighborhood and remaining in the same industry by working in another part of the city. Except for some highly specialized and highly paid workers, neighborhood attachment, according to Reynolds, outweighs industry attachment.[3]

The second study of a labor market is also based upon interviews

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[1]Lloyd G. Reynolds, The Structure of Labor Markets (New York, 1951) pp. 78-79.

[2]Reynolds, p. 52.

[3]Reynolds, p. 53.

in a New England city. This city, too, is unidentified, but is apparently Nashua, New Hampshire. After a textile plant suddenly curtailed its operations in 1948, interviewers questioned a sampling of discharged workers about their willingness to take work outside the city. In a group of 144 workers that constituted the main part of the sampling, 35% had found new jobs by the time they were interviewed. For this 35% the question was largely hypothetical. In response to the question, 55% of the entire group said they were not willing to take jobs outside the city. Of the 45% that were willing, 49% added the important qualification that the job must be within commuting distance. Interpretation of these responses is complicated by the fact that 17% of the group resided outside the city. The dominant trend is clear, however: "Even in a period when the local employment outlook was bleak, ... unemployed workers generally tried to get along the best they could without moving."[1]

Similar evidence appears in a recent study of workers at several New England textile mills that closed. Slightly more than half of all workers interviewed were unemployed at the time of survey. Interviewers asked a number of displaced workers in five New England cities whether they would leave the area in which they lived if they knew of a job elsewhere. Of the 1157 workers questioned on this point, 58.3% said they would not, 27.3% said they would, and 14.3% gave no answer. This sample included 625 women, many of whom were married and could presumably not make an independent decision to move. Among the men alone, 48.3% said

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[1]Charles A. Myers and George P. Shultz, The Dynamics of a Labor Market, (New York, 1951), p. 198.

they would not leave the area in which they were living, 36.7% said they would, and 14.8% did not answer.[1] Even among the men, a majority of those answering were unwilling to move out of the area. This question is another severe test of residential mobility, because it tends to measure attachment to the total community rather than to a specific house or neighborhood. Yet the strength of attachment to the community even in a period of unemployment hints also at a strong attachment to the immediate environment of home and neighborhood that makes people unwilling to move away.

A study summarizing research in labor mobility has concluded from some of the above sources and from a number of others that "the worker's strongest attachment is to his community, that he is considerably less strongly attached to a particular occupation, and even less so to an industry."[2] New Haven experience mentioned above suggests that enough of this community attachment applies to the neighborhood level so that many people will not move to other parts of the same city in order to continue working in the same industry.

A final opinion survey to consider is an early one, conducted in 1942 by the Princeton University Bureau of Urban Research. In a nationwide sampling of 2490 people, only 12% said they would want to live closer to where they work if housing comparable to their current residences were available. When people living within five miles of their jobs are eliminated from the sampling,

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[1]William H. Miernyk, Inter-Industry Labor Mobility, (Boston, 1955), p. 28.
[2]Herbert S. Parnes, Research on Labor Mobility (New York, 1954), p. 79.

> only one-third of those residing from 5 to 20 miles away wish they could live nearer their place of employment. For most people, any disadvantages of peacetime commutation are more than offset by the "living" advantages of home communities located away from the usual business, commercial, and industrial areas of urban employment.[1]

Another source of information about residential mobility results from studies of the consequences of plant relocation. The best of these studies is an unpublished dissertation by Richard S. Bolan. His data comes from the employee records of four factories that moved from central city to suburban locations in the Boston metropolitan area. The original sampling of employees was 350; 149 of these worked in both the central and suburban plants. Some of the remaining 201 left their jobs; many continued to work for one firm that still maintained some operations in the central city. Only 40 of the 149 (27%) had changed their residences at the time of the survey[2]; an average of three years had passed since the plants were relocated.

The relatively low proportion of workers that moved is in itself an indicator of residential "stickiness". Bolan went further, however, to investigate whether these workers were predisposed to move because of factors not related to commuting. From Rossi's Why Families Move, he adapted the index of mobility potential. This index is based on such characteristics as family size and age of worker; it is related to Rossi's contention that residential mobility results chiefly from changes in family size. Bolan found that 80% of the workers that moved belonged

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[1]Melville C. Branch, Jr., Urban Planning and Public Opinion (Princeton, 1942), p. 19.

[2]Richard S. Bolan, "The Journey to Work in Recently Suburbanized Industry," unpublished dissertation (M. I. T., 1956), p. 34.

to the high mobility potential classification in terms of the index.[1] This point is important: workers that moved did not constitute a random sample of all workers. Of the 27% that moved, a majority probably wanted to move for reasons other than a desire to reduce commuting. At the same time, plant relocation may well have hastened the move, or may have made the final difference between mobility potential and actuality.

The information presented unfortunately does not allow a determination of where individuals who moved located their new residences. The resultant pattern for all employee residences indicates a movement in the direction of the new suburban locations, but this shift may result largely from the availability of new housing in the suburbs and a general residential movement out of the central city. In any event, Bolan's study confirms that most workers do not tend to change residences primarily in order to be near their jobs. The experience of two London factories, cited in Kate K. Liepmann's The Journey to Work, leads to the same conclusion. One had relocated seven years before the survey, the other two years before. In both cases, the residential distribution of employees still reflected the old plant location.[2]

Thus the evidence indicates that for industrial workers, residences are only slightly mobile in relation to work location. Because employees do not tend to adjust their places of residence in order to be near their jobs, the central hypothesis of this study is closer to confirmation.

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[1]Bolan, p. 49; sum of categories II and IV.

[2]Kate K. Liepmann, The Journey to Work (London, 1944), pp. 134, 145.

With residences relatively immobile in regard to work places, the residential pattern of a metropolitan area must determine the pattern of industrial locations. This residential pattern will, therefore, establish an outer limit for industrial development.

Chapter Three

How Workers Relate Residence and Job Locations: II The Concept of Opportunities

Worker motivations alone cannot explain residential and commuting characteristics. Each worker, regardless of his preferences, finds himself limited by the choice of opportunities available. Since this choice is always finite, preferences must compromise with the alternatives that are offered. Desirable housing within prices the worker can afford may be available at only a few locations. Jobs may be obtainable at only a few locations. The more restricted opportunities are, the more they will distort natural preference areas. This concept of opportunies must supplement the above findings concerning residential mobility in order to produce a comprehensive picture of the relationship between homes and work places. Limitations among opportunities, together with the characteristics of residential mobility, explain many of the seeming contradictions in journey-to-work studies; they also explain some of the residential patterns that seem to suggest high mobility of homes in relation to work places.

The theory that opportunities modify preferences has many applications in the study of locational patterns; it also has many confirmations. In an analysis of metropolitan labor markets, William Goldner attributes occupational differences in commuting patterns to an underlying availability of opportunities:

> These findings [i.e., prior studies] suggest that workers' normal preference areas increase in scope as they move up the

> scale of occupations. Babysitters seek their jobs in the neighborhoods near their homes. Unskilled workers, being unspecialized, are more likely to encounter an acceptable job nearer to where they live. Skilled workers have to work for employers using their specialized skills among a far-flung group of establishments. Atomic physicists generally do not have cyclotrons near their houses, although it is possible that they can better afford to move to or near their work locations.[1]

Many observed residential patterns of workers can be explained in terms of the opportunities available to people in different occupations. Liepmann describes the recruiting experience of a London manufacturing company in these terms. Female employees live mostly near the plant, while male employees live in scattered locations throughout a wider area. "The main reason," she says, "is that girls are engaged in less skilled occupations and can, therefore, be found in any residential area."[2] A high proportion of the male employees, on the other hand, are specialized workers that have to be drawn from a wider labor market.

Housing opportunities may be one reason why a high percentage of industrial workers live close to their jobs. Carroll's position that workers tend to adjust their residences to their work places derives largely from observed residential distributions that show most workers living within a few miles of their jobs. Yet several other explanations of this phenomenon are plausible. One is that labor turnover gradually tends to fill positions with local people. When neighborhood residents leave distant jobs, they may seek work near home before looking further away. One study of public housing residents in Chicago found indications

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[1]William Goldner, "Spatial and Locational Aspects of Metropolitan Labor Markets," American Economic Review, XLV (March 1955), 122.

[2]Liepmann, p. 145.

that people who moved into the projects kept their old jobs until lay-offs occurred, and then looked for new work closer to the projects.[1]

Another explanation is in terms of housing opportunities. Housing in the vicinity of industrial plants is often cheap housing. As such, it may be the only housing that many industrial workers can afford. In speaking of the tendency of low-income groups to live nearer their work than high-income people, Carroll suggests that the location of cheaper housing near industrial plants may be the cause.[2] Since a sizable proportion of unskilled and semi-skilled workers in industry earn relatively low incomes, the proximity of factories and low-income housing in cities may be largely responsible for the nearness of many workers' residences to their jobs. Suburban industrial sites, however, are usually near higher-income housing. Implications of this point will be explored after further examination of how limited opportunities mold workers' preferences.

Two further illustrations emphasize the importance of opportunities in determining the distance between home and work. First, the varying number of opportunities in rural and urban situations bring about a distinct difference in the distances workers commute to rural and urban plants. In rural areas, both population and industrial jobs are spread thinly over a wide region. Assembling a work force, therefore, requires inducements to draw employees from a large area, because enough people

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[1]Robert F. Whiting, "Home-to-Work Relationships of Workers Living in Public Housing Projects in Chicago," Land Economics, XXVIII (August 1952), 288.

[2]Carroll, "Home-Work Relationships of Industrial Employees," p. 109.

cannot be found nearby. For the potential industrial worker, finding a job generally means travelling a long distance because factories are scarce in rural territory. The results of a World War II survey at 48 war plants follow expectations:

> Generally, the employees at rural plants travel about ten miles farther than those at urban plants. Ninety percent of employees at rural plants travel over ten miles, and their weighted average distance is 15.4 miles. Only twenty percent of employees at urban plants travel more than ten miles and their weighted average distance is 6.5 miles.[1]

Negro workers demonstrate in their choices of homes and jobs the effects of limited opportunities. Having fewer alternatives available to them, they must compromise their preferences to a much greater extent than white workers. As a result, the locations of their homes in relation to work places often reflect the availability of housing and jobs rather than workers' locational preferences. When housing and commuting information is tabulated separately for Negroes and whites, characteristics of the two groups differ sharply. In the Chicago public housing study cited previously, white workers tended to occupy public housing units near their old neighborhoods; Negroes often moved far from their old neighborhoods to take advantage of a rare opportunity for better housing in any project. After moving to a public project, white workers who changed jobs tended to take work near their new homes; Negro workers took jobs all over as new opportunities became available.[2] In a different

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[1] Theodore M. Matson, War Worker Transportation (1943), pp. 23-24.
[2] Whiting, p. 288.

Chicago survey, white workers employed in outlying areas tended to live closer to work than those employed in the central business district. Among nonwhites, no clear relationship between workplace centralization and commuting distances could be found.[1]

A combination of the concept of opportunities with Rossi's explanation of residential mobility provides the key to understanding what happens when workers move. Rossi found that when a family selects a new residence, they first narrow the range of choice to homes that meet their major requirements. Space needs, which generally bring about the desire to move, must be satisfied first. Then costs and outside appearance narrow the choice still further. Of the homes that meet these requirements, the family tends to select one that also allows reasonable transportation to work.[2] This explanation is simplified, but the important point is that other criteria precede nearness to work when a family chooses a new home. In order for workers to move closer to their jobs, two factors are critical. First, the workers must be predisposed to move: this situation will occur chiefly because of family needs. Second, housing that meets the workers' needs must be available closer to their jobs than their previous homes were: the opportunity must occur nearer to their jobs rather than further away.

In Bolan's study of plant relocation, he found the first condition satisfied for the minority that moved when he tested mobility potential

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[1] Beverly Duncan, "Factors in Work-Residence Separation: Wage and Salary Workers, Chicago, 1951," American Sociological Review, XXI (February 1956), 1951.

[2] See above pp. 17-19, and Rossi, p. 164.

by means of an index derived from Rossi's work. Housing that workers found satisfactory was available in suburban Boston: thus the mobile workers moved closer to their jobs rather than further away. Since only a minority of workers moved, however, the residential shift toward work places was very limited.

The contrasting experience of a steel mill in Fontana, California has led Carroll to the conclusion that workers will shorten their trips to work by moving closer to their jobs. A significantly higher percentage of employees at this steel mill lived in Fontana in 1948 than in 1947. This change, according to Carroll, constitutes evidence of "a rapid adjustment of residence to work place."[1] This change can be explained reasonably on the different grounds of mobility among workers and opportunities in Fontana. Carroll mentions that Fontana had much new housing under construction at this time: housing opportunities were close to work. As a result of wartime housing shortages, much potential mobility had built up prior to 1947. By 1947, new housing opportunities converted potentiality to actuality, and workers moved.

Other plants have had a different kind of experience: when employees moved, they did not reduce the trip to work to a minimum by their choice of new housing. Adams and Mackesey cite two interesting incidents. At Oak Ridge and Kingsport, Tennessee during the war, people living in trailers near the plant where they worked would move 25 or 30 miles away if they could find a house. In this case, opportunities resulted in

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[1]Carroll, "Home-Work Relationships of Industrial Employees," pp. 153, 154.

lengthening the trip to work. More recently, workers in a factory several miles south of Poughkeepsie have chosen homes six miles north of the city rather than in a project near the factory that they consider less attractive.[1] When a new plant located in Santa Ana, California, a similar experience followed. A subdivider built several hundred homes within walking distance of the factory, but most employees who relocated chose homes scattered within a radius of about forty miles from the plant, selecting them "where their wives wanted to live."[2]

What remains of Woodbury's assumption that workers seek housing close to their jobs is hardly enough for industrialists to use in deciding plant location. When workers are predisposed to move, and when they can satisfy their needs and preferences with housing near their jobs, they may move close to their work places. Since World War II, both necessary conditions have sometimes operated to bring about worker relocation near new suburban plants. Yet a businessman who assumes that workers will move close to a new plant (i.e., that both necessary conditions exist), assumes a great risk. Generally, most workers will not be predisposed to move at any given time. For those that are potentially mobile, financial needs are among the criteria that determine residential selection. In suburban territory, middle-income workers may find suitable housing opportunities, but will low-income workers be able to satisfy their needs? These aspects of the locational problem suggest the

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[1] Adams and Mackesey, p. 27 fn.

[2] Stuart P. Walsh, "Changing Labor Patterns and Decentralization," in Problems of Decentralization in Metropolitan Areas (Proceedings of First Annual University of California Conference on City and Regional Planning), (Berkeley, 1954), p. 29.

desirability of reducing risk by assuming only very limited residential mobility. Considering residences relatively immobile in regard to work places is not merely a conservative assumption, however, but also an assumption that accords with past experience.

Chapter Four

Regularities in the Choice of Home and Work Locations

The extent to which opportunities can modify natural preferences raises the question of whether any regularity is possible in locational patterns of home and work. This question would seem to depend largely on the scale involved. In a small area (or an undeveloped large one), the lack of opportunities could distort preference patterns considerably. In a larger (or more developed) region, with more opportunities available, workers can find satisfactory choices within their spatial preference limits: they need not, for example, go 35 miles from home to find a satisfactory job. Thus in a metropolitan area, which is the scale for this study, greater regularity is likely. On the other hand, the range of opportunities available, especially in a metropolitan area, may bring about fluctuations well inside the outer limits of preference areas. Workers may cluster jobs and residences at certain points because of attractive opportunities, while other geographic locations within normal preference ranges may attract few workers.

This study is concerned chiefly with establishing outer limits for industrial development in metropolitan areas. Consequently, distortions in preferences for job and residence locations that occur within the outer limits do not weaken the hypothesis. But an explanation is needed to indicate why workers will observe any self-imposed outer commuting limits in the face of varying opportunities. One reason is simply that they are not willing to sacrifice limitless amounts of time every day in

travelling to and from work. Most surveys of commuting characteristics unfortunately express the journey to work in terms of distance rather than time. From the worker's point of view, however, time is probably more important. In many circumstances, distance may represent time fairly well, and the empirical evidence of various surveys suggests very strongly a high degree of uniformity among commuting limits in both time and distance (see appendix A).

Workers will also set commuting limits for reasons other than convenience or the desire for more free time. Long automobile trips to work carry with them the possibility of delays in bad weather. Adams and Mackesey found in questioning their sample of long-distance commuters that about 40 percent had some desire to move closer to work. In two areas surveyed in detail, the great majority of those willing to move closer reported that they had lost seven days or more of work in the previous year because of travel conditions.[1] Goldner concludes that in spite of varying opportunities that tend to expand or contract preference areas, the limits for any given worker are not extremely flexible:

> In the main, and particularly for industrial wage earners, the normal preference area is fairly invariable for a worker who has mastered a particular set of occupational characteristics for which he has an expectation regarding the rate of pay, during a period of economic stability.[2]

Even if workers have personal preferences that determine their commuting limits, individual differences among workers would seem to have the power of preventing any uniform pattern from developing. Yet several

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[1] Adams and Mackesey, pp. 63, 120.

[2] Goldner, p. 123.

factors encourage the development of an aggregate uniform pattern. One is that the personal standards by which workers establish preference areas are at least in part culturally determined. Workers communicate their standards to one another, and probably decide what is suitable partly on the basis of what conditions the neighbors accept as suitable. A second consideration is that any sizable minority of workers with a firm preference area may effectively limit the outer boundary for industrial development. Low-income workers come particularly to mind, for if they cannot find suitable housing in the suburbs, the outer limit of their preference area may fall well inside the preference area of middle-income workers that live in the suburbs. Then industries requiring low-income workers will be unable to locate further out than the edge of the low-income preference area. To the extent that all industries require some low-income workers, the aggregate labor market boundary cannot extend much beyond the commuting area of low-income workers living in the central city. Whiting cites a tentative confirmation that these conditions have influenced industrial location in the Chicago area:

> Although the trend of industry toward far outlying areas around Chicago has been reflected in a 20-percent rise in values for modern plant sites, values in the old factory districts have not declined. This suggests that a shortage of low-income workers may be experienced in the suburban areas where new housing is beyond the means of even many middle-income families.[1]

Adams and Mackesey, among others, have sensed the general agreement in standards among different occupational groups. They suggest that for most workers, the drawing power of higher-paying opportunities probably

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[1]Whiting, p. 290.

does not exceed a commuting distance of 15 to 20 miles.[1] Goldner has sensed the general area of agreement in commuting standards, as well as the varying limits that extend around the fringe. Because the fringe is not sharply defined, labor market boundaries necessarily have an arbitrary nature about them:

> The aggregation of workers' preference areas results in a mound which tapers off beyond the boundary of the urban area. The limits of the labor market are therefore not physical, but rather are established by the value judgments of workers....
>
> In empirical terms the external limits of the labor market should be conceived as existing well beyond the built-up area of the city, of being subject to changing influences in time, of differing among occupational-skill levels, and of being arbitrarily determined in the sense that a few workers' preference areas will exist at and extend beyond the arbitrarily established limit.[2]

Since the limit does not contain all preference areas, it is arbitrary. But if the limit reflects the preference area of most workers in the various occupations that industry requires, this arbitrary limit sets a very effective outer boundary for concentrated industrial development.

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[1] Adams and Mackesey, p. 43.

[2] Goldner, p. 127.

Chapter Five

Testing Metropolitan Patterns of Industry and Residence

If the residential distribution of industrial workers does in fact control the outer limits of concentrated industrial development, the characteristics of metropolitan areas at any given time should contain confirmations of this controlling influence. In order to test existing metropolitan patterns for confirming evidence, a method akin to the concept of population potential has been devised. Population potential, as developed by John Q. Stewart and others, is a measure indicating "the influence of people at a distance," or "the intensity of the possibility of interaction."[1] Testing the ideas presented in this study requires a measure to indicate the influence of industrial workers within commuting distances of their homes. Such a measure would indicate the relative possibilities for interaction between workers at their residences and jobs at any given location. It would constitute an index of manufacturing labor potentially available at any point for which the measure is made.

The population potential concept relates the influence of people inversely to a power of the distance intervening between the people concerned and the point where their influence is to be measured. When this influence is a matter of the likelihood of their taking work at some

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[1] John Q. Stewart, "A Basis for Social Physics," Impact of Science on Society, III (Summer 1952), 120; Gerald A. P. Carrothers, "An Historical Review of the Gravity and Potential Concepts of Human Interaction," Journal of the American Institute of Planners, XXII (Spring 1956), 96.

point, however, the measure should incorporate what is known about commuting-distance preferences. Consequently, the first step in constructing an index to measure manufacturing labor potential is to compile information on the proportions of industrial workers who will travel various distances to their jobs.

The localities to be studied are the Boston and Hartford standard metropolitan areas as defined by the United States Census of Population of 1950. Characteristics will be determined from the 1947 Census of Manufactures and the 1950 Census of Population. In gathering information on commuting distances, therefore, all available surveys pertinent to conditions in Boston and Hartford in the 1947-1950 period have been included. A few surveys that reflected inapplicable conditions are omitted from this compilation. The results of eight surveys, presented as item 10 in Appendix A, indicate a strong consistency in the proportion of employees travelling the same distances to work in different areas. These results suggest the following distribution as a reasonable and realistic assumption about the drawing power of industrial firms in the areas to be studied for 1947-1950:

65% of employees will live less than 5 miles away.

20% of employees will live from 5-10 miles away.

10% of employees will live from 10-20 miles away.

In order to derive an index of the labor pool available to a specific place, one must first determine the total number of industrial workers living in each of these distance zones (0-5 miles away, 5-10 miles, 10-20 miles), regardless of where these workers may currently be employed.

The industrial population residing in each zone will receive a different weighted value, in accordance with the influence that workers within each zone exert at the place for which an index is desired. Because workers in the three zones tend to be hired in the proportion of 65:20:10, industrial populations of each zone will be weighted accordingly. The total number of industrial workers in the 0-5 mile zone will be multiplied by 65 per cent; in the 5-10 mile zone by 20 per cent; in the 10-20 mile zone by 10 per cent. The results of these three multiplications will be added together to constitute an index value: .65 (number of industrial workers living 0-5 miles away) plus .20 (number of industrial workers living 5-10 miles away) plus .10 (number of industrial workers living 10-20 miles away). Since the influence of workers living more than 20 miles away is relatively minor --5 per cent under the assumed distribution -- industrial population beyond the 10-20 mile zone will be omitted from the calculation of index values.

The values assigned to each zone result from the 65:20:10 distribution of industrial workers indicated by surveys of worker residences applicable to 1947-1950 conditions in the Boston and Hartford metropolitan areas. As conditions change, these proportional relationships would have to be reconsidered in the light of newer information. A recent survey of workers at one suburban plant in the Boston metropolitan area reflects the impact of new highways upon the distances workers will travel. The results, shown in item 11 of Appendix A, would suggest a different distribution for analyzing the contemporary suburban pattern of industry and residence. In this instance, only 36% of the employees live less

than five miles away, while 30% live 5-10 miles away, and 24% live 10-20 miles away.

Once a method of determining the index of manufacturing labor potential has been established, metropolitan areas may be tested to explore the relationship between industrial locations and workers' residences. This study has maintained that the distribution of employee homes controls the outer limits of concentrated industrial development in metropolitan areas. The approach in testing existing metropolitan patterns will be to identify the places where industry has concentrated, and to calculate the index of manufacturing labor potential for these places. The lowest index value found among these communities may be taken as the minimum index value necessary to allow concentrated industrial development as of 1947-1950. Places in the metropolitan area that do not meet this minimum index value are presumably outside the zone where industry may develop at a high density, unless conditions change considerably from what they were in the 1947-1950 period.

On the other hand, a high index value is not enough to insure that any community will achieve a high level of industrial development. We may expect to find many communities with low industrial densities as of the 1947-1950 period in spite of high index values. Since factors other than accessibility to industrial workers also influence the location of industrial sites, index values above the critical minimum represent a condition that is necessary but not sufficient for industrial development.

When the critical minimum index value has been determined, it can constitute an important tool for understanding industrial growth. In

the Boston metropolitan area, cities and towns near the new circumferential highway, route 128, have attracted much new industry in recent years. Information on economic growth in the vicinity of this highway allows an investigation of new industrial development in a rapidly expanding part of the Boston region. For this investigation, communities near the highway will be divided into two groups: those below the critical minimum index value for 1947-1950, and those above it. The experiences of these two groups of communities will provide an interesting test of the concepts behind this minimum index value for labor potential.

The Hartford metropolitan area allows a similar examination of industrial growth in places of high and low labor potential. Records of industrial employment in 1947 and 1955 are available for all communities in the Hartford metropolitan area. These communities will be divided into high and low labor potential categories on the basis of 1947-1950 labor potential index values. Growth from 1947 to 1955 will be investigated separately for places in each category.

Testing the Boston Metropolitan Area

Since the first objective was to identify the zone of concentrated industrial development, some measure of concentration had to be adopted: cities and towns with manufacturing employment densities above one hundred workers per square mile were considered places of concentrated industrial development. In the Boston metropolitan area, the 1947 Census

of Manufactures supplied employment information for the forty cities and towns that had 10,000 or more inhabitants in 1940. The number of workers employed by manufacturing industries in each community was divided by the land area in square miles. Twenty-four of these 40 cities and towns had the required density of over 100 manufacturing employees per square mile. (For the results of these various calculations, see Appendix B.) Twenty-five communities with 1940 populations below 10,000 were not included in the 1947 Census of Manufactures. These 25 remaining communities of the total of 65 in the Boston metropolitan area were inspected for manufacturing density characteristics on the basis of Massachusetts Division of Employment Security employment records for 1954 and 1955; none had densities as high as 100 manufacturing workers per square mile.[1]

The next step was to calculate index values of manufacturing labor potential for the 24 communities having high manufacturing employment densities. For this purpose, the number of manufacturing employees living within 0-5 miles of each community, 5-10 miles, and 10-20 miles had to be obtained. The 1950 Census of Population[2] provided data on

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[1] This measure of industrial concentration represents a compromise between the information desired and the data readily available. Ideally, manufacturing employment totals for small spatial units of equal area would have helped locate points of industrial concentration more effectively than manufacturing employment for entire cities and towns. Because some communities contain large tracts of vacant land or park land, industrial concentrations in part of the town may not be revealed by calculating manufacturing density for the entire land area included within the community. The method employed appears to locate most places of industrial concentration within the metropolitan area, but densities of manufacturing employment by community are not completely reliable in indicating the position and extent of industrial development within small spatial areas.

[2] U.S. Bureau of the Census, U.S. Census of Population: 1950, II, "Characteristics of the Population," Part 21, Massachusetts (Washington, 1952), Table 35.

manufacturing employees by place of residence for cities over 10,000. Towns over 10,000 presented a special problem, since comparable data was not available. Massachusetts Department of Commerce town monographs contain other usable information for these towns, however. On the basis of 1950 U. S. Census tract returns, the town monographs list occupational characteristics of the resident population. Two occupational categories are related most closely to industrial employment: the categories of "craftsmen, foremen, and kindred workers" and "operatives and kindred workers". For cities that had industrial employment data available from the U. S. Census reports and occupational data available from Department of Commerce monographs, the sum of resident workers in the craftsmen-foremen and operatives categories consistently approximated the number of resident industrial workers. Therefore, the craftsmen-foremen and operatives categories were summed for all towns over 10,000 to give the approximate resident industrial population.

Thus all communities in the Boston metropolitan area over 10,000 in population were covered by data on resident industrial workers. Communities outside the standard metropolitan area but within 20 miles of Boston metropolitan cities and towns were covered in the same way: information was obtained for all communities over 10,000, either from the U. S. Census directly or from Massachusetts monographs based on U. S. Census tract returns. Several communities in Rhode Island had to be included because of their proximity to the Boston metropolitan area: U. S. Census information was available for the Rhode Island places.

For the twenty-four communities having high industrial employment

Table 1

Ranking of Cities and Towns in Boston Standard Metropolitan Area With 1947 Manufacturing Employment Greater than 100 Workers per Square Mile

Column A		Column B	
Index Values of Manufacturing Labor Potential, 1950 (In hundreds; for full values, add 00 to each figure)		Density of Manufacturing Employment (Workers employed in manufacturing per square mile of land area), 1947	
Somerville	1105	Cambridge	4429.4
Cambridge	1081	Everett	3319.9
Boston	925	Watertown	2701.2
Winchester	813	Chelsea	2455.9
Medford	788	Lynn	2454.6
Malden	758	Boston	2355.8
	4th quartile		
Melrose	737	Somerville	1903.3
Everett	733	Malden	1098.2
Chelsea	717	Waltham	874.7
Watertown	676	Salem	813.3
Revere	668	Quincy	452.1
Peabody	553	Norwood	397.5
	3rd quartile		
Waltham	548	Peabody	387.6
Lynn	545	Newton	308.0
Newton	524	Medford	272.4
Salem	512	Beverly	269.0
Wakefield	469	Wakefield	231.4
Woburn	467	Winchester	216.4
	2nd quartile		

Table 1

(continued)

Column A		Column B	
Quincy	453	Framingham	212.7
Braintree	415	Braintree	139.8
Danvers	384	Danvers	133.0
Beverly	366	Woburn	126.4
Norwood	343	Melrose	122.8
Framingham	247	Revere	100.5

1st quartile

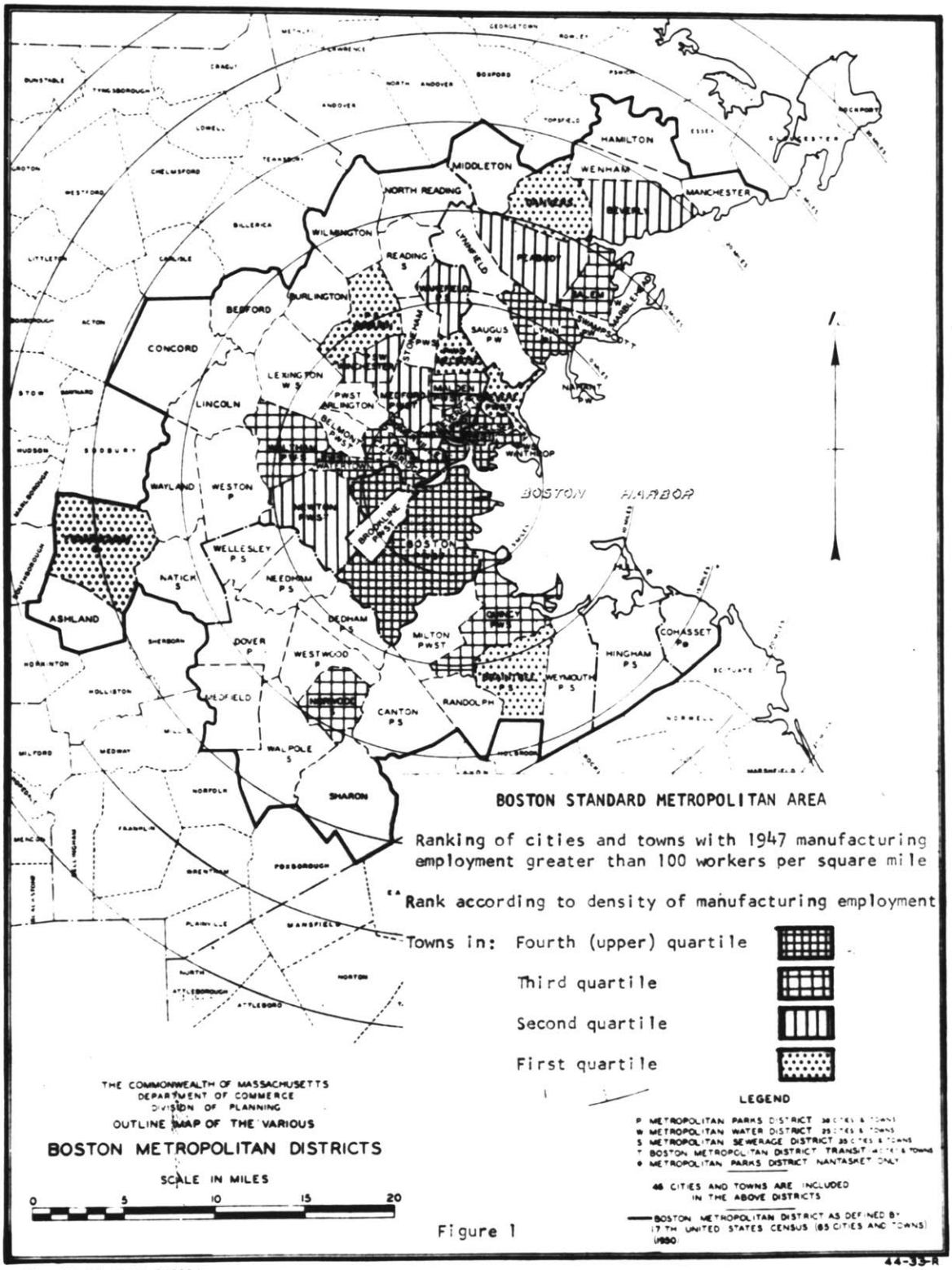

Figure 1

Form 22. 1M-12-56-919004

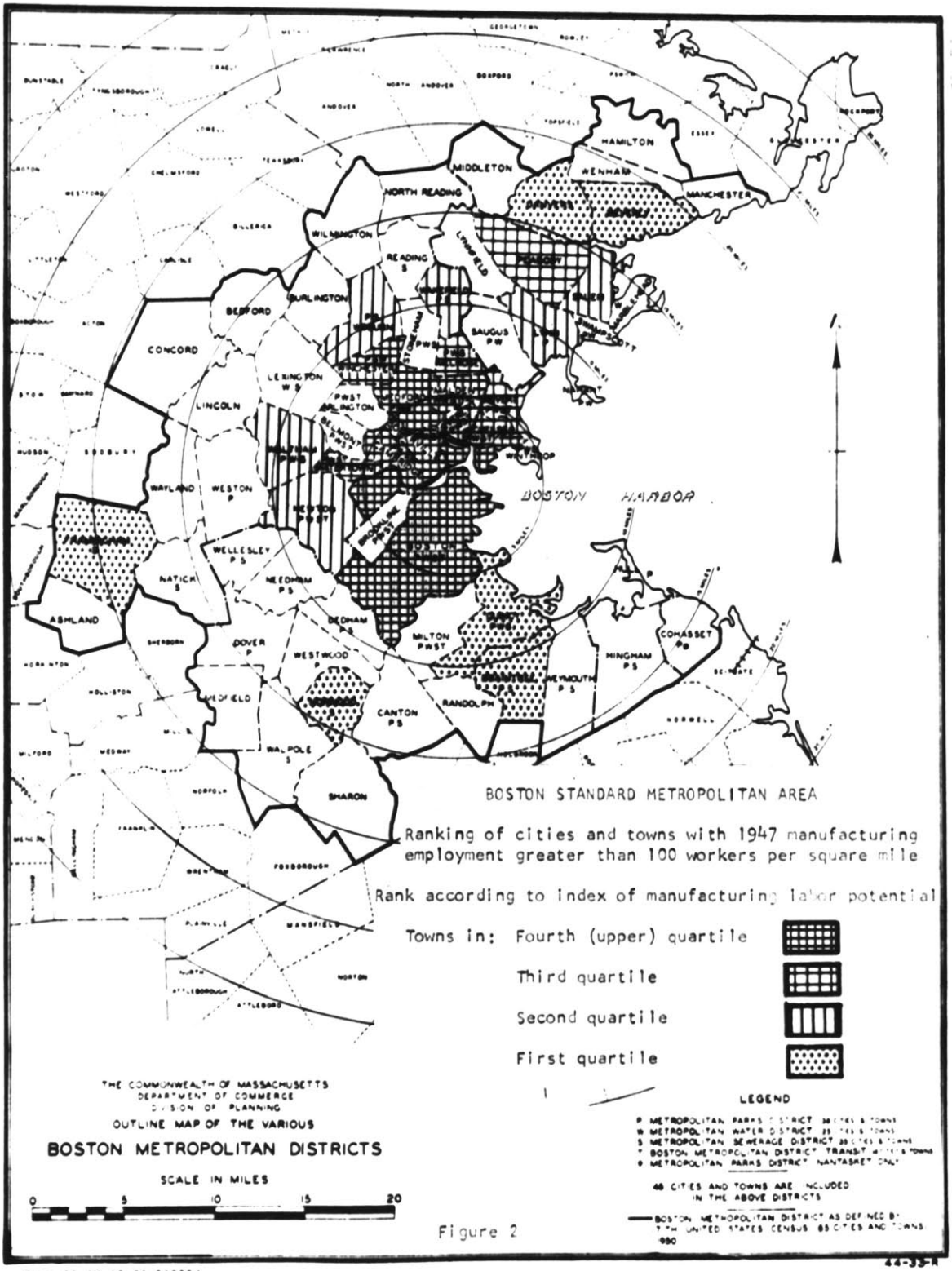

Figure 2

Form 22. IM-12-56-919004

densities, totals were obtained of manufacturing workers living 0-5 miles away, in the 5-10 mile zone, and in the 10-20 mile zone. Population distribution maps helped to determine the zone in which a city or town belonged. Communities were treated as units; industrial populations were not split between two zones. The zone in which a majority of the town population lived received credit for the entire number of resident industrial workers. Zone distances were direct mileages over land areas; road mileages were not computed. When Boston harbor intervened in the drawing of distance zones, nearest land mileages were used. After zone totals were obtained, the number for each zone was weighted as described above, and the weighted figures were totalled to give the index value for manufacturing labor potential.

The results of these computations are given in Column A of Table 1, where the twenty-four communities are arranged by quartiles in order of their manufacturing labor potential index values. Figures 1 and 2 present the same results in a graphic form that indicates the spatial pattern of manufacturing density and manufacturing labor potential. An important point to note is that Figure 2 ranks only the same 24 cities and towns as Figure 1. Consequently, Figure 2 is not a picture of the 24 cities and towns with highest index values, but a picture of the index values of the 24 cities and towns that rank highest in manufacturing density.

The first purpose of these calculations was to establish the critical minimum index value needed for concentrated industrial development.

Framingham, with a density of 212.7 manufacturing workers employed in the town per square mile of land area, has the lowest index value: 247. Before accepting this value as the minimum necessary to support an industrial concentration, one must note its relationship to the other index values given in Column A. It is markedly lower than the next higher value, 343; in fact, the gap between 247 and 343 appears to mark one of the breaking points in the series. Only two other intervals between consecutive ranks in the series are greater: the intervals between Peabody and Revere (553 to 668) and Winchester and Boston (813 to 925).

Spatial relationships shown in Figure 1 may explain why Framingham was able to maintain a high industrial density in 1947-1950 with an index value much lower than any of those obtained for other communities with high manufacturing densities. Framingham is relatively isolated from other manufacturing communities. It is surrounded by areas of low manufacturing density, both in the Boston metropolitan area and on the western side of the metropolitan boundary. Thus although the labor potential rating for Framingham is low, it faces little competition for whatever labor is within commuting range. As a result, Framingham can capitalize on relatively limited resources, while other communities that must compete with their neighbors for industrial labor require greater resources to obtain a comparable labor supply.

The Framingham rating of 247 is probably too low to serve as a critical minimum value, unless a community can parallel Framingham

in dominating the nearby labor market. Under more normal circumstances, when communities compete with one another for labor, a higher value must be achieved. The index series in Table 1 suggests that a value of 300, approximately mid-way between Framingham and the next higher community, would be a reasonable minimum value to postulate as a condition for achieving a manufacturing employment density above 100 workers per square mile.

If an index value of 300 is the critical minimum for concentrated industrial development in the Boston metropolitan area, many implications can be drawn from the index characteristics of this region. First, relatively few communities in the standard metropolitan area fall below this index score. Calculations were not made for every community in the area, but several outlying places for which index values were computed have scores below 300: Manchester, 109; Medfield, 227; Framingham, 247; Sharon, 247; Wayland, 260; Natick, 269. Other metropolitan communities that appear to have scores below 300, but for which index values were not computed, are Ashland, Cohasset, Concord, Hamilton, Hingham, and Walpole. All these communities lie in the extreme outer fringe of the metropolitan area. Thus the residential distribution of industrial workers in the Boston metropolitan area sets a rather far-flung outer limit to industrial development. This metropolitan area has a widely dispersed industrial population; further, the outer portions of this metropolitan area can also draw upon the labor force residing in such external communities as Brockton, Lawrence, and Lowell. Consequently, the metropolitan area suffers from no scarcity of places accessible to a sufficient labor force for industrial development.

Among the communities that score above 300 on the labor potential index, relatively little correlation may be found between the score and the density of industrial development. The small extent of correlation points out that once the critical amount of accessibility to labor is achieved, other factors determine how much industrial development will follow. Several communities with scores above 300 had not attained a manufacturing density of 100 employees per square mile by the 1947-1950 period. Index values for some of these communities are: Burlington, 386; Dedham, 410; Needham, 415; Reading, 416; and Lexington, 462. Different reasons explain why the development pattern does not necessarily follow the index value. Lexington has had the reputation of being opposed to new industry in the past. Burlington has been generally undeveloped, with few community facilities available. Winchester, another example of the lack of correlation, has achieved a manufacturing density above 100 employees per square mile: with 216.4 employees per square mile, it ranks eighteenth in manufacturing density in the metropolitan area. Yet in manufacturing labor potential, it ranks fourth among the 24 communities of high manufacturing density with a score of 813. Winchester has clearly not capitalized fully upon its exceptionally favorable accessibility characteristics. Instead, it has become largely a dormitory suburb inhabited by people who work in Boston. Housing has pre-empted land in Winchester.

Whether the development of Winchester for commuter housing rather than industry should be regretted depends upon many factors and values other than accessibility characteristics to industrial labor. Because

the labor potential score is very high, industry in Winchester could provide jobs within reasonable commuting distances of many workers. Since jobs are not available in Winchester, some of these potential workers for Winchester probably have to travel further to job locations elsewhere. In the total metropolitan scheme, however, their extra travel may be cancelled by travel savings among Winchester commuters to Boston who might live still further from Boston if Winchester contained more industry and less housing. Techniques similar to those employed in compiling a manufacturing labor potential index could conceivably be employed to derive indices of labor potential for workers in other kinds of economic activities. In this way, one could construct a more comprehensive picture of metropolitan accessibility characteristics that might allow a more general evaluation of the existing pattern.

In summary, index values of manufacturing labor potential that are above the critical minimum value for industrial development correlate with manufacturing densities only to a small extent. Because accessibility to labor is only one force in a field of metropolitan forces, correlation between labor potential values and manufacturing densities should not be expected. The planning value of the manufacturing labor potential index lies more in the concept of the critical minimum value. To determine whether this critical value plays a controlling part in the development of new industry, recent experience in the vicinity of route 128 has been analyzed by means of the labor potential index.

As a result of widespread interest in economic development along the new circumferential highway, the Massachusetts Department of Commerce has

Table 2

High Growth Communities in Vicinity of Route 128

(Over 500 new employees in manufacturing resulting from leasing or construction of new quarters, expansions of old facilities, 1954-1956)

	Number of New Employees	Index Values of Manufacturing Labor Potential, 1950
Waltham	3872	548
Needham	1800	415
Dedham	1350	410
Norwood	1184	343
Burlington	703	386
Newton	625	524
Natick	525	269

obtained information on plant construction, plant expansion, and the establishment of new companies in a large number of communities close to route 128.[1] This information covers the period from March, 1954 to December, 1956. Since substantial sections of route 128 opened several years before the survey began, a number of new plants and new companies are not included. Nevertheless, the 1954-1956 period covered was a time of great industrial growth near the highway; as such, this period should reflect industrial potentialities in the communities surveyed.

The first step in analyzing this growth data was to tabulate the number of new employees in each town. These employees were hired by new companies or were added to the staffs of old companies as a result of plant expansion. Available data does not indicate the net amount of new employment in each town, but merely new employment resulting from the establishment of new companies, the construction of new plants, and the expansion of old industrial facilities. Employees hired by non-manufacturing establishments (e.g., headquarters offices, research facilities) were omitted from the tabulation.

Tabulations for thirty communities in the Boston metropolitan area and three just outside the area indicated that seven communities had each added more than 500 manufacturing employees during the 1954-1956 period. The figure of 500 appeared to be a breaking-point; the next lower number of employees added was 285, then 196 (see Appendix C). Index values of manufacturing labor potential were then obtained for these seven communities, as shown in Table 2. Six of these seven high-growth

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[1] Information furnished by Mrs J. L. Olmstead, Division of Research, Massachusetts Department of Commerce.

communities had index values over the critical minimum of 300. More significantly, the only community to move from a manufacturing density below 100 workers per square mile as of 1947 to a new density above 100 workers per square mile had an index value above 300: Dedham, with a score of 410, went from 28.7 workers per square mile in 1947 to 157.2 workers per square mile on the basis of new employment from 1954-1956 (the new density figure assumes no other changes from 1947 to 1956).

Then the thirty Boston metropolitan communities were inspected to determine whether any others were likely to have index values below 300. Manchester appeared to have a low manufacturing labor potential: when calculated, the score was 109. Of the communities shown in Table 2, one had a score below 300: Natick, with 269. Natick acquired a slightly over 500 new industrial employees, although it did not reach the level of concentration above 100 workers per square mile. Manchester, on the other hand, added no new employees even though route 128 passes directly through the town. All three communities surveyed outside the Boston metropolitan area appeared to have very low index values, and all had only small employment gains. Two were excluded from index value calculations because their locations away from route 128 may have accounted for their small gains in employment. The highway passes through Gloucester, however, and the index score computed for Gloucester was 57. Industrial growth in Gloucester accounted for 285 new employees, but the growth was specialized in an unusual way.

Gloucester is an example of a special kind of industrial location, that of resource-oriented industry. All but six of the 285 new employees

work for firms that package fish or manufacture fish products. Gloucester is of course a fishing port. (The other six employees, incidentally, work for a sail and awning company, located in Gloucester probably for nearness to their particular market.) Resource-oriented industry is an exception to most of the concepts developed in the course of this study. If resources determine the location of a particular industry, firms in this industry are not free to locate at any place in the metropolitan area where labor requirements may be met. Thus resource-oriented industries cannot be expected to conform to the locational pattern determined by the residential distribution of industrial workers. Experience in Gloucester points up the limitations of this study in dealing with unspecified industries throughout: separate studies of different kinds of industries might reveal a series of more distinct locational patterns than the combined pattern of all metropolitan industries. Probably certain industries respond very sharply to the residential pattern of industrial workers, while others do not.

Another interesting consideration suggested by some of the data for communities near route 128 is the changing labor market brought about by new highway construction. In computed index values, the numbers of workers living in the various distance zones are weighted for each zone according to the proportions found in commuting surveys applicable to 1947-1950 conditions. New highway construction can alter these proportions significantly. The 1955 survey of a Waltham plant (item 11, Appendix A) reflects the distribution of workers after the construction of route 128. For distance zones of 0-5 miles, 5-10 miles, and 10-20 miles, the

distribution is 36.0%, 29.9%, and 24.3%. The distribution used in index value computation for 1947-1950 was 65%, 20%, and 10% for the same zones. Obviously, new highway construction can decrease the proportion of workers coming from nearby locations and increase the proportion coming from longer distances.

A computation of the number of manufacturing workers living in the zones of different distances from a number of communities can indicate which communities are most likely to benefit from new highway construction in their areas. The computations for Boston metropolitan communities (Appendix B) indicate that of all places for which calculations were made, Burlington had the greatest number of industrial workers in the zone 10-20 miles away. For Burlington, the industrial population within 5 miles is only 5,638; the industrial population 5-10 miles away is 67,007; 10-20 miles away it is 215,083. Thus Burlington can benefit greatly from new highway construction that brings about a shift in relative importance from nearby zones to those further away. The survey of communities near route 128 demonstrates that Burlington has indeed been affected by this change in labor potential. According to Massachusetts Division of Employment Security records cited in the Department of Commerce monograph on Burlington, manufacturing employment was only 46 in 1954. During the 1954-1956 period of the route 128 survey, Burlington gained 703 employees in seven newly constructed manufacturing plants. At the same time, two industrial parks were organized, encompassing a total of 83 acres.

Table 3

Ranking of Cities and Towns in Hartford Standard Metropolitan Area With 1947 Manufacturing Employment Greater than 100 Workers per Square Mile

Column A		Column B	
Index Values of Population-Commuting Potential, 1950 (In hundreds; for full values, add 00 to each figure)		Density of Manufacturing Employment (Workers employed in manufacturing per square mile of land area), 1947	
Hartford	2358	Hartford	2117.2
East Hartford	2226	East Hartford	948.7
West Hartford	2190	West Hartford	253.3
Manchester	1050	Manchester	121.0

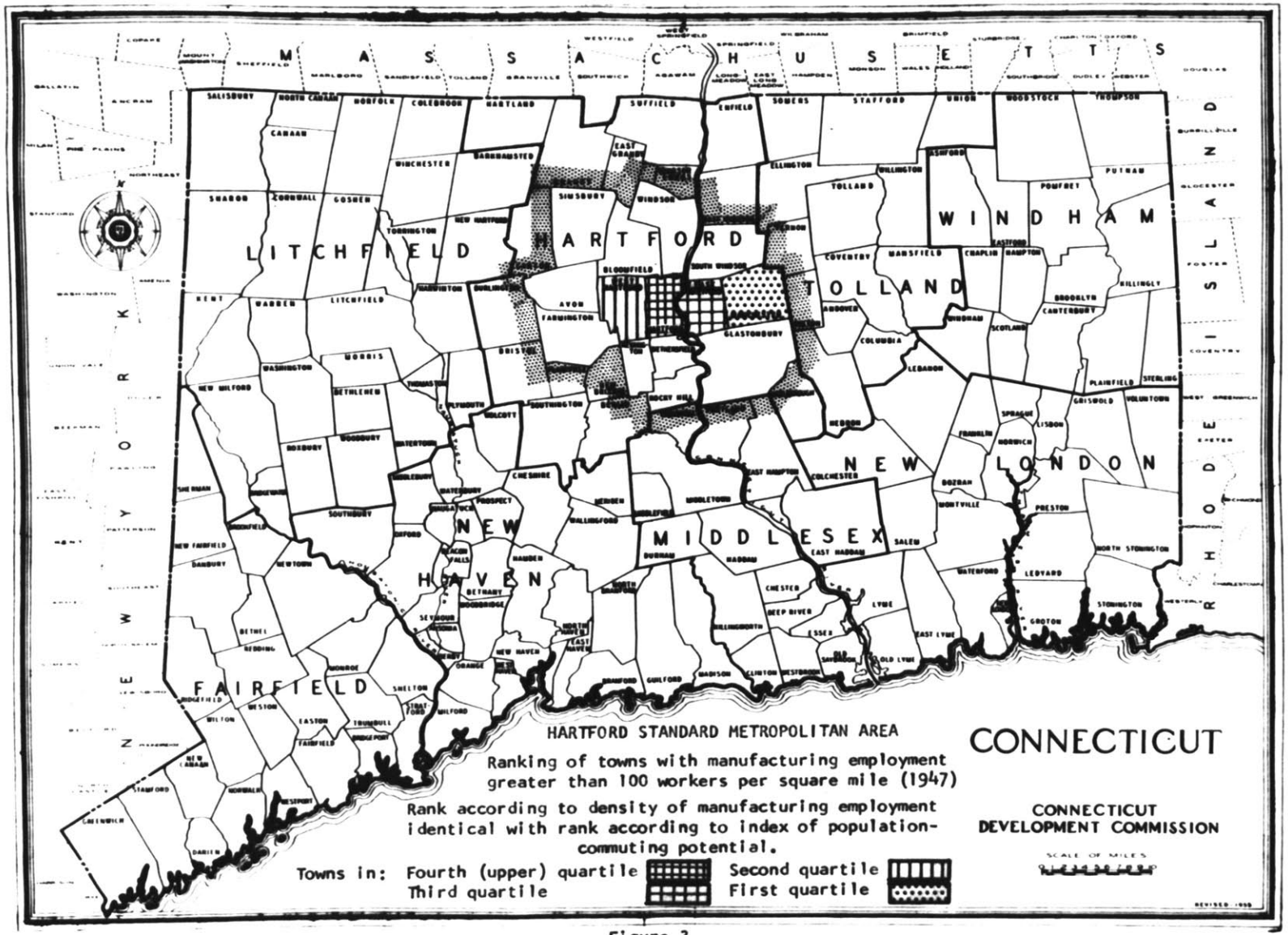
MASSACHUSETTS
NEW YORK
RHODE ISLAND
LITCHFIELD
HARTFORD
WINDHAM
TOLLAND
NEW LONDON
NEW HAVEN
MIDDLESEX
FAIRFIELD
HARTFORD STANDARD METROPOLITAN AREA
Ranking of towns with manufacturing employment greater than 100 workers per square mile (1947)
Rank according to density of manufacturing employment identical with rank according to index of population-commuting potential.
Towns in: Fourth (upper) quartile
Third quartile
Second quartile
First quartile
CONNECTICUT
CONNECTICUT DEVELOPMENT COMMISSION
SCALE OF MILES

Figure 3

Testing the Hartford Metropolitan Area

Applying similar techniques to the Hartford standard metropolitan area is a simpler process, partly because the area includes fewer communities and partly because data limitations have imposed a more limited scope on this part of the study. The 1950 Census of Population does not include data on industrial workers by place of residence for any localities in the area except Hartford. Consequently, an index of manufacturing labor potential could not be obtained. Instead, total population of each town was used, and the computing process was otherwise identical with that developed for Boston. The results therefore constitute an index of population potential weighted to reflect commuting characteristics in the same proportions used for Boston as of the 1947-1950 period. If the percentage of industrial workers in the population were the same in all towns, this index would coincide with an index of manufacturing labor potential. To the extent that manufacturing workers are not distributed in proportion to the total populations of towns, this index deviates from a true index of manufacturing labor potential.

With industrial concentration defined once again as a density of more than 100 workers employed in manufacturing per square mile, four communities in the metropolitan area constituted the zone of concentrated industrial development in 1947.[1] Table 3 and Figure 3 indicate the density and potential characteristics of these four communities. The rank

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[1]Employment information furnished by Connecticut Department of Labor to Adams, Howard and Greeley; included in Regional Planning Study: Farmington River Valley Region, 1955-1957, pp. 110-111, for both 1947 and 1955.

Table 4

Ranking of All Cities and Towns in Hartford Standard Metropolitan Area

Column A		Column B		Column C	
Index Values of Population-Commuting Potential, 1950 (In hundreds; add 00)		Density of Manufacturing Employment, 1947 (Workers per square mile)		Density of Manufacturing Employment, 1955 (Workers per square mile)	
Hartford	2358	Hartford	2117.2	Hartford	1726.8
East Hartford	2226	East Hartford	948.7	E. Hartford	1488.8
West Hartford	2190	West Hartford	253.3	W. Hartford	335.8
Wethersfield	1951	Manchester	121.0	Manchester	125.2
Farmington	1602	Rocky Hill	57.4	Newington	101.5
Newington	1480	Farmington	17.5	Rocky Hill	53.8
Windsor	1306	Newington	16.0	Bloomfield	52.6
Avon	1219	Bloomfield	13.4	Windsor	35.3
S. Windsor	1172	Glastonbury	8.6	Farmington	17.1
Rocky Hill	1143	Simsbury	6.6	Wethersfield	15.9
Bloomfield	1116	Wethersfield	4.5	Glastonbury	14.3
Manchester	1050	Windsor	2.6	Simsbury	12.7
Glastonbury	1018	S. Windsor	2.0	S. Windsor	4.3
Simsbury	787	Avon	0.0	Avon	0.6

of these towns is the same in terms of potential as it is in terms of manufacturing density.

As in the Boston analysis, the main purpose of the manufacturing density computation was to ascertain the critical minimum index value in terms of potential that can support a concentration of industry. Manchester has an index value of 1050, which may be taken as the critical level.

Because fewer towns were involved in the Hartford calculations, index values of population-commuting potential could be computed for every community in the metropolitan area. Results are given in Column A of Table 4, which indicates that only Glastonbury and Simsbury were below the critical minimum level in 1950. Again the question arises of whether residential distribution is so arranged that almost the entire metropolitan area is accessible to a sufficient labor force for concentrated industrial development. In the Hartford area, this situation seems to prevail even more strikingly than in the Boston area, for a number of outlying communities were below the Boston critical index level. In the Hartford area, even parts of Glastonbury exceed the critical minimum value, but the potential assigned to each town is based upon the geographic center. The Hartford analysis, however, is very much open to criticism because the index reflects total population rather than industrial workers in the population. In some metropolitan communities, such as West Hartford, industrial workers are actually only a small proportion of the total population. If information were available on the manufacturing labor distribution, the critical level of worker potential might

exclude a larger part of the metropolitan area from the zone for concentrated industrial development.

Connecticut data makes possible an analysis of changes in manufacturing employment over an eight-year period for all communities in the metropolitan area. Columns B and C of Table 4 present information on manufacturing employment density. One significant feature is that the only town to rise above a density of 100 workers per square mile from 1947 to 1955 had a 1950 population-commuting potential value well above the critical minimum of 1050. Newington went from a manufacturing density of 16.0 workers per square mile in 1947 to 101.5 workers per square mile in 1955. Its score on the potential index was 1480, sixth highest in rank among potential index scores for the metropolitan area.

Another feature to note is the growth experience of the two communities below the critical minimum level. Both Glastonbury and Simsbury gained a small number of additional workers. Although their index values were below the 1947-1950 critical minimum, their manufacturing densities were also well below 100 in 1947, so that industrial growth could still capitalize further upon existing labor potential. Nevertheless, growth in other parts of the metropolitan area overshadowed these two communities, with the result that they dropped slightly in rank of manufacturing density from 1947 to 1955.

The Hartford tests suffer from severe limitations. Data deficiencies prevent the index of population-commuting potential from expressing the residential distribution of industrial workers. Consequently, the influence of this residential distribution cannot be gauged accurately on the basis of

Hartford experience. Hartford information nevertheless provides some confirmation for the notion that a critical minimum degree of labor accessibility can be ascertained empirically, and that communities below this minimum level cannot support concentrated industrial development.

Chapter Six

Conclusions

Analyses of the Boston and Hartford metropolitan areas leave several problems still unresolved. Chief among these is the question of how extensive a zone in metropolitan areas can meet the labor accessibility requirements necessary for concentrated industrial development. In the Boston area, all but a small number of outlying communities appear to lie within the zone for possible industrial development. The zone in which industries can locate in large numbers is thus quite extensive. Since residential distribution of industrial workers -- together with the commuting limits that these workers observe -- has determined the extent of this potential zone for industry, if the zone is large the distribution must also be scattered over a wide area. An important question is whether other metropolitan areas have similar residential characteristics, and thus have similarly far-flung boundaries within which industrial concentrations may develop. Examining the Hartford area does not provide further insight into this question, for inadequate data about Hartford does not allow a zonal determination based upon the residential pattern of industrial workers.

The Boston residential pattern may very well be more characteristic of older metropolitan areas than of areas that have grown considerably in recent years. Recent growth is more likely to result in the predominance of expensive new residences in the suburbs; Boston has a mixture of new and old homes in suburban places. The mixed suburban pattern, with

its more diverse price range, enables many industrial workers to live outside the central cities, and thus allows industries to locate in outlying parts of the metropolitan area. A predominance of new and expensive homes in the suburbs would limit many workers to residences in the core cities: under these circumstances, the outer boundary for concentrated industrial development would be drawn closer to the center of the metropolitan area, and many fringe communities would be excluded.

The question presented here could be resolved if information were available on the residential and industrial patterns in several metropolitan areas that have grown recently more than Boston has. Ideally, this information should be available for small spatial units (such as towns in the Boston area) to allow relatively precise determination of differences in labor potential and manufacturing density. Since census information does not serve this purpose adequately outside of New England, one fruitful approach might be to develop methods for analyzing land use map information along lines employed in this study.

If the Boston pattern should prove to be typical of most metropolitan areas, the concept of residential distribution as a factor determining the outer limits of industrial development would have little applicability on the metropolitan scale. In this event, the tools developed here might be useful chiefly for spatial and locational problems on the periphery of metropolitan areas or beyond. New town or industrial estate location beyond the normal metropolitan boundaries might well rest partly upon analyses of manufacturing labor potential at different points.

Another question that the Boston and Hartford analyses have resolved

only in part is that of how the critical minimum level of potential affects industrial development over a period of time. Some useful insights have come from the route 128 survey and from the Hartford comparisons between 1947 and 1955, but information was not readily available on other significant variables affecting industrial location in these areas. Data comparable to the material available for communities near route 128 would serve well if supplemented by additional information on such factors as community attitudes toward industry and sites available. Such data would also allow separate analyses to be made of different industries, their configurations at any given time, and their responsiveness to residential distribution.

The dynamics of industrial development require fuller treatment than this study has undertaken to give. As the case of Burlington has suggested, components of the labor potential index must receive different weights as means of transportation change. Techniques employed in this study could provide a way of determining the effects of past changes in transportation upon labor accessibility. Once again, however, gathering comparable data over a period of time would present a difficult problem.

Although this study has left certain questions unanswered and has perhaps raised some new problems, it has also presented much evidence to resolve a number of issues related to the residential mobility of labor and the relationship between homes and work places of industrial employees. In brief, evidence on how industry chooses sites indicates that employers will attempt to locate jobs close to workers. Motivation surveys among workers and studies of labor mobility demonstrate that workers will

generally not move in order to be close to jobs. Thus the residential pattern is relatively immobile in relation to work places, while new work places will tend to approach residential locations. Information presented in the first four chapters of this study establishes that the residential distribution of industrial workers is a key factor determining the location of new industry.

Analyses of the Boston and Hartford metropolitan areas yield preliminary confirmation that a critical minimum level of potential labor accessibility is necessary for concentrated industrial development. These analyses demonstrate that the residential pattern of workers endows various places with high or low accessibility to labor. Certain areas of low accessibility fall below the minimum level of labor potential: these areas may obtain some new industry, but they have been unable to reach high levels of industrial concentration in the time periods studied.

If residences were highly mobile in relation to work places, accessibility characteristics could change easily as workers moved to be close to new plants located in areas of low labor potential. Quite certainly, workers will not generally adapt their residences to new jobs in this way. Accessibility characteristics may nevertheless change as modes of transportation shift or as worker population becomes redistributed for reasons other than a desire to move closer to work places. Questions of dynamics in the residential-industrial relationship, however, are mainly beyond the scope of this study. With these questions, one approaches also the problem of how the residential-industrial relationship fits into the field of other metropolitan accessibility requirements that influence

spatial characteristics and land uses; but beyond the development of a measuring technique that may facilitate analysis of other kinds of accessibility, this study must stop short of a solution for the broader problem suggested here.

Appendix A

Some Suggested and Observed Commuting Standards

1. Desirable maximum travel time to work: 30 minutes. T. Ledyard Blakeman, preface to Detroit Metropolitan Area Regional Planning Commission, Home Location Pattern of Industrial Workers in the Detroit Region, p. i.

2. Desirable maximum: 30 minutes. William W. Johnston, "Travel Time and Planning," Traffic Quarterly, X (January 1956), 74.

3. Proposed standards for metropolitan dispersal:
   50% of workers to be within 20 minutes' drive or 30 minutes' bus ride to work.
   75% of workers in large cities and 90% in smaller cities to be within 30 minutes' drive or 40 minutes' bus ride to work.
   "Reduction of Urban Vulnerability," Part V of Report of Project East River (New York, 1952), Appendix V-B, p. 9b.

Note: Above time standards may be converted to distances by means of travel speeds cited in Johnston, "Travel Time and Planning": 20 mph average for major roads in built up areas; 35 mph on freeways or highways in open areas. In built-up areas, a drive to work of 30 minutes equals 10 miles; 20 minutes equals 6 miles.

4. Standards for commuting outward from central cities of various sizes:
   2,500 - 10,000 people: 4 miles
   10,000 - 50,000 people: 10 miles
   50,000 - 200,000 people: 15 miles
   over 200,000 people: 25 miles
   National Resources Planning Board, Industrial Location and National Resources (Washington, 1943), p. 348.

5. Assumed commuting limit to be used in site selection: 30 miles. Yaseen, p. 111.

6. Assumed commuting limit used in case study of plant location: 25 miles.
   Gilmore, p. 18.

7. World War II experience:
   Generally 2/3 to 3/4 of workers lived within 10 or 15 miles of plant; 90% lived within 20 miles. Most workers at old, established plants lived within 5 or 10 miles. In established industrial areas, the outer limit of commuting was nearer 20 than 30 miles.
   Adams and Mackesey, pp. 28, 29.

8. Willingness to move closer to work:

In 1942 Massachusetts survey, proportion of workers willing to move closer to jobs reached peak of 24.0% in 20-24.9 mile zone. Zones further distant showed smaller proportion of workers willing to move, but apparently because of inaccurate data collection (workers often not living at the home addresses they gave).

Carroll, "Some Aspects of Home-Work Relationships of Industrial Workers," p. 418.

9. Postwar experience:

Drawing power of better wages probably does not exceed the 15-20 mile zone.

Adams and Mackesey, p. 43.

10. Residential Distribution of Workers in Mileage Zones From Work Locations

	Year of Survey	0-5 Miles	5-10 Miles	10-15 Miles	15-20 Miles	20 + Miles
1.	(1942)	65.0%	18.0%	11.0%		7.0%
2.	(1942)	67.5	19.5	6.0	2.2	4.8
3.	(1943)	71.0	19.7	5.7	3.6	
4.	(1950)	69.5	18.3	4.7	3.0	4.5
5.	(1951)	56.9	17.0	7.1	8.2	10.8
6.	(1951)	79.4	12.3	4.4	2.0	1.9
7.	(1951)	77.4	10.5	3.3	5.7	3.0
8.	(1953)	51.9	30.8	6.4	6.2	4.7
	Average of	67.3 (8)	18.3 (8)	5.4 (7)	4.6 (6)	5.2 (7)
				10.0		
11.	(1955)	36.0	29.9	15.1	9.2	9.8

Sources:

10. 1. Branch, p. 61, Region 1 (Northeast). Percentages of people not answering, not working and working in more than one place have been eliminated. Percentages of people answering have been adjusted proportionally to total 100% sampling for Northeast region: 708 cases.

2. Carroll, "Some Aspects of Home-Work Relationships of Industrial Workers," p. 416. Survey of 72,048 workers in Massachusetts, 1942.

3. Adams and Mackesey, p. 94. Survey of 8 plants in the Binghamton-Johnson City-Endicott, New York area, 1943, conducted by Broome County War Transportation Committee.

4. Leo F. Schnore, The Separation of Home and Work in Flint, Michigan (1954), p. 16. Percentages here derived by linear interpolation from

Schnore's distance categories. Survey of 65,970 workers at 6 General Motors plants in Flint Area, 1950.

5. Adams and Mackesey, p. 51. Survey of 39,990 production workers in Albany-Schenectady-Troy area, 1951.

6. Adams and Mackesey, p. 51. Survey of 21,196 production workers in Binghamton, New York, 1951.

7. Adams and Mackesey, p. 51. Survey of 8,997 production workers in Elmira, New York, 1951.

8. Detroit Metropolitan Area Regional Planning Commission, Home Location Pattern of Industrial Workers in the Detroit Region (1955), p. 10. Survey of about 87,000 workers at 7 plants in Detroit metropolitan area, 1953. Percentages derived by linear interpolation from other distance categories.

11. "Workers Commute Long Distances When Good Highways Are Available: Raytheon-Waltham Plant Survey," Massachusetts Division of Employment Security Quarterly Statistical Bulletin, January-March 1956, pp. 6-8. Survey of 7,825 employees at Waltham plant.

Appendix B Boston Computations - Density and Potential

	(1) Mfg. Employees 1947 Average for year	(2) Land Area Sq. Mi.	(3) Mfg. Employees /sq. mi.	(4) Mfg. Population within 5 mi.	(5) Mfg. Pop. 5-10 mi.	(6) Mfg. Pop. 10-20 mi.	(7) Potential	(8) From State Monograph, Sum of Craftsmen & operatives
Arlington	292	5.18	56.3					4928
Ashland	-							
Bedford	-							
Belmont	80	4.59	17.4					2250
Beverly	4,073	15.14	269.0	20,516	20,559	192,172	36,600	
Boston	101,722	43.18	2355.8	104,347	85,218	76,575	92,500	
Braintree	1,915	13.70	139.8	17,330	90,367	121,441	41,500	3004
Brookline	445	6.62	67.2					2848
Burlington	-	11.84		5,638	67,007	215,083	38,600	(480)
Cambridge	27,684	6.25	4429.4	140,324	51,253	66,096	108,100	
Canton	-							
Chelsea	4,568	1.86	2455.9	60,412	136,466	51,189	71,700	
Cohasset	-							
Concord	-							
Danvers	1,814	13.64	133.0	19,485	29,082	199,283	38,400	2200
Dedham	301	10.50	28.7	7,415	125,904	109,693	41,000	2550
Dover	-							
Everett	11,155	3.36	3319.9	62,857	134,185	560,20	73,300	
Framingham	5,087	23.92	212.7	7,184	6,030	187,671	24,700	4611
Hamilton	-							

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Hingham	-							800
Hull	-							
Lexington	114	16.48	6.9	18,468	70,083	202,434	46,200	1402
Lincoln	-							
Lynn	25,700	10.47	2454.6	40,946	56,511	166,360	54,500	
Lynnfield	-							
Malden	5,579	5.08	1098.2	64,339	135,329	69,313	75,800	
Manchester	-	(7.72)	[illegible].1	240	22,397	62,270	10,900	(240)
Marblehead	269	4.40	261.1					1031
Medfield	-	14.43		433	15,536	193,246	22,700	(433)
Medford	2,236	8.21	272.4	66,205	129,768	97,878	78,800	
Melrose	581	4.73	122.8	55,670	143,471	88,301	73,700	
Middleton	-							
Milton	144	13.10	11.0					1730
Nahant	-							
Natick	842	14.88	56.6	8,121	20,454	174,844	26,900	2573
Needham	929	12.50	74.3	12,011	116,294	104,086	41,500	1617
Newton	5,514	17.90	308.0	26,084	130,673	93,030	52,400	
N. Reading	-							
Norwood	4,162	10.47	397.5	5,798	83,162	138,861	34,300	3248
Peabody	6,376	16.45	387.6	40,044	45,996	201,465	55,300	
Quincy	7,461	16.51	452.1	19,060	95,906	136,768	45,300	
Randolph	-							
Reading	507	9.84	51.5	8,743	79,330	200,105	41,600	1555
Revere	598	5.95	100.5	49,759	145,780	52,751	66,800	

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Salem	6,498	7.99	813.3	41,075	33,141	180,651	51,200	
Saugus	299	10.58	28.3					3065
Sharon	-	23.58		2,676	16,785	196,095	24,700	(477)
Somerville	7,480	3.93	1903.3	143,961	63,557	42,288	110,500	
Stoneham	594	6.03	98.5					1752
Swampscott	42	3.08	13.6					1069
Wakefield	1,701	7.35	231.4	15,445	101,624	165,418	46,900	2872
Walpole	-							
Waltham	10,855	12.41	874.7	27,012	131,061	109,598	54,800	
Watertown	10,967	4.06	2701.2	54,396	119,540	82,866	67,600	5393
Wayland	-	15.28		3,094	30,475	178,774	26,000	(521)
Wellesley	225	10.05	22.3					937
Wenham	-							
Weston	-							
Westwood	-							
Weymouth	1,335	16.70	79.9					4511
Wilmington	-							
Winchester	1,277	5.90	216.4	66,213	139,760	102,838	81,300	1192
Winthrop	110	1.56	70.5					1889
Woburn	1,625	12.86	126.4	18,710	79,205	187,444	46,700	

Sources:

1. U.S. Bureau of the Census, Census of Manufactures: 1947 (Washington, 1950), III, "Statistics by States," pp. 279-280 (Massachusetts, Table 2). Includes urban places with population of 10,000 or over in 1940.

2. Ralph G. Wells, ed., New England Community Statistical Abstracts (Boston, 1953), pp. 25, 29.

3. Column (1) divided by column (2).

4, 5, 6. U.S. Bureau of the Census, U.S. Census of Population: 1950, II, "Characteristics of the Population," Part 21, Massachusetts and Part 39, Rhode Island. Table 35 for cities over 10,000. For other communities over 10,000, figures in column (8) were used.

7. .65 of column (4) plus .20 of column (5) plus .10 of column (6).

8. Massachusetts Department of Commerce town monographs. Sum of "craftsmen, foremen and kindred workers" plus "operatives and kindred workers" from occupational characteristics. Information given here for all communities over 10,000 not included in U.S. Census of Population, II, Table 35. Figures for communities below 10,000 enclosed in parentheses and used only for computing potential values for these communities.

Appendix C

Communities Covered in Route 128 Survey

	(1) New Employees in Mfg. 1954-56	(2) Acreage of New Industrial Estates, '50-'56	(3) Potential
Bedford	20		
Beverly	121		366
Billerica*	47		
Braintree	60		
Burlington	703	83	386
Canton	14		
Danvers	42		384
Dedham	1350	28	410
Gloucester*	285		57
Hamilton	0		
Lexington	40		462
Lincoln	0		
Lynnfield	0		
Manchester	0		109
Natick	525	95	269
Needham	1800	580	415
Newton	625	65	524
Norwood	1184		343
Peabody	196	125	553
Randolph	67		
Reading	64		416
Rockport*	3		
Stoneham	0		
Wakefield	172	310	469
Waltham	3872	230	548
Wayland	125		260
Wellesley	26		
Wenham	0		
Weston	0		
Westwood	0	271	
Wilmington	186		
Winchester	28		813
Woburn	179		467

*Outside Boston standard metropolitan area

Sources:

(1) From information furnished by Mrs J.L. Olmsted, Research Division, Massachusetts Department of Commerce.

(2) Planning Division, Massachusetts Department of Commerce, "Industry's New Map of Massachusetts," covering 1950-1956.

(3) Derived as column (7), Appendix B.

Appendix D Hartford Computations

	(1) Mfg. Employees 1947	(2) Mfg. Employees 1955	(3) Land Area Sq. Miles	(4) Mfg.Empl. per Sq. Mile 1947	(5) Mfg.Empl. per Sq. Mile 1955	(6) Popu-lation 0-5 mi.	(7) Popu-lation 5-10 mi.	(8) Popu-lation 10-20 mi.	(9) Potential empl. 47-55	(10) Change in mfg. empl. 47-55
Avon	0	13	20.77	0.0	0.6	10,197	369,012	414,601	121,900	13
Bloomfield	364	1,433	27.24	13.4	52.6	22,401	305,351	359,738	111,600	1,069
E.Hartford	17,304	27,155	18.24	948.7	1,488.8	266,863	87,593	315,797	222,600	9,851
Farmington	429	419	24.55	17.5	17.1	90,746	325,903	360,432	160,200	-10
Glastonbury	474	784	54.87	8.6	14.3	13,926	281,095	366,257	101,800	310
Hartford	38,110	31,083	18.00	2,117.2	1,726.8	279,121	152,686	238,589	235,800	-7,027
Newington	220	1,394	13.74	16.0	101.5	144,879	81,630	374,505	148,000	474
Rocky Hill	687	644	11.97	57.4	53.8	18,504	385,652	251,908	114,300	-43
Simsbury	200	389	30.52	6.6	12.7	7,993	72,955	588,615	78,700	189
S. Windsor	58	126	29.00	2.0	4.3	50,115	303,402	238,917	117,200	68
W. Hartford	5,540	7,343	21.87	253.3	335.8	237,742	173,556	298,213	219,000	1,803
Wethersfield	60	214	13.43	4.5	15.9	230,366	108,232	238,074	195,100	154
Windsor	78	1,066	30.16	2.6	35.3	31,725	321,319	457,249	130,600	988

Sources:

(1), (2) Adams, Howard and Greeley, Regional Planning Study: Farmington River Valley Region, 1955-1957, pp. 110-111. Based upon information from Connecticut Department of Labor.
(3) State of Connecticut Register and Manual: 1945-46 (Hartford, 1946).
(4), (5) Columns (1) and (2) divided by column (3).
(6), (7), (8) U.S. Bureau of the Census, U.S. Census of Population: 1950, II,"Characteristics of the Population," Part 7, Connecticut, Table 6.
(9) .65 of column (6) plus .20 of column (7) plus .10 of column (8).
(10) Adams, Howard and Greeley, pp. 110-111.

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