A THEORY OF LOCAL LABOR MARKET DELIMITATION

By

RICHARD WILLIAM POOLE

Bachelor of Science
The University of Oklahoma
Norman, Oklahoma
1951

Master of Business Administration
The University of Oklahoma
Norman, Oklahoma
1952

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A THEORY OF LOCAL LABOR MARKET DELIMITATION

Thesis Approved:

Joseph J. Klos
Thesis Adviser

James A. Clayton

John J. Klein

Ansel M. Sharp

Robert MacVean
Dean of the Graduate School

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CHAPTER I

INTRODUCTION

Choice of Subject

In recent years there has been growing concern over the inadequate treatment accorded the space dimension in economic theory. This view is reflected by Walter Isard:

> In economics, emphasis is placed upon scarce resources, the pricing mechanism by which these scarce resources are allocated to diverse uses, and the associated income determining and distributing processes. Economics is among those social sciences which have achieved a significant depth of analysis. But the core area, at which it achieves maximum penetration, is primarily centered around the behavior of business concerns, consumers, and financial and governmental institutions. Economics rarely obtains depth of analysis in that area which touches upon the broad influence of space and physical environment upon man's behavior and land utilization patterns.[1]

A more detailed statement of the spatial problem for economic theory is provided by Joseph L. Fisher.

> Now let us turn briefly to a consideration of a few of the potentially more promising lines along which regional science (or regional analysis, to use the term I prefer) may contribute to economics generally. First, I think regional analysis can illuminate economic theory at many points by incorporating the element of geographic space and economic distance into the formulations. Production theory, distribution theory, monetary theory, to name a few, do not ordinarily have space dimension. Trade theory alone of the conventional divisions of economic theory has dealt directly with the matter. And in this case very frequently theory

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[1] Walter Isard, "Regional Science, the Concept of Region, and Regional Structure," Papers and Proceedings of the Regional Science Association, Vol. II, 1956, p. 15.

has run in terms of two countries, or one country and a number of other countries, with each country thought of as a single point in space. Of course, there has been some tradition of economic location theory, mainly in Germany but occasionally making an appearance in the theoretical writings of economists in other countries. Adam Smith was concerned with the extent of the market; numerous English and other theorists had a good deal to say about international trade; and German historical economists in the 19th century were concerned with the growth and changing inter-relations among states. Coming closer to the present, Ohlin has given us a comprehensive study of interregional trade, and Lösch, Christaller, and Vining have theorized abstractly about spatial relationships. Hoover's book on the location of economic activities contains a comprehensive survey of the subject, and now the work of Walter Isard and his colleagues (for example, Moses, Kuenne, Dunn) has begun to bring much greater attention to space and distance in economic theory. Despite the increasing tempo of attention to the space dimension and regions in economic theorizing, I think a great deal remains to be done before one can say with assurance that the spatial characteristics of economic behavior have found adequate and comprehensive formulation in economic theory generally.[2]

The delimitation of local labor markets, which of necessity must incorporate space dimension, has not been subjected to rigorous economic theorizing. The absence of a developed theoretical framework in this area came to the author's attention as the result of undertaking an empirical study of commuting patterns and labor characteristics for a facility located in Oklahoma that employs some 19,000 individuals. Prior to initiating this empirical study a survey of the literature for similar studies was undertaken in order to take full advantage of the knowledge gained from past experience. The review of the literature yielded numerous empirical studies.[3] As might be expected, their scope varied considerably. What was not anticipated, however, was the degree of variation in approach and diversity of conclusions. A

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[2]Joseph L. Fisher, "Potential Contributions of Regional Science to the Field of Economics," Papers and Proceedings of the Regional Science Association, Vol. III, 1957, p. 19.

[3]For a partial listing of such studies see the Selected Bibliography.

uniform concept of a local labor market was nonexistent. In turn a variety of techniques were employed in depicting local labor markets. Finally, as a result of the foregoing two variations there emerged a variety of conclusions concerning the major determinants accounting for the geographic extent of a local labor market. In an endeavor to have some criterion by which to evaluate these diverse results, the survey of the literature was expanded to include all theoretical works in the field. For all intents and purposes the search proved unproductive. The author was unable to discover an integrated theoretical treatment of local labor market delimitation.

Two key points emerge from the foregoing discussion. First, economic theory has in general neglected the space dimension. Although increased attention has been devoted to the solution of this problem much remains to be done. Second, local labor market analysis was identified as a specific problem area requiring such theoretical development. For these two reasons the development of a theory of local labor market delimitation that incorporates the spatial dimension into economic theory is deemed appropriate and timely.

Purpose of the Study

The purpose of this study is to construct a theory of local labor market delimitation. This endeavor in turn stems from a desire to accomplish two objectives. First, to add depth of analysis in one area of economic theorizing that touches upon the influence of space. As Walter Isard points out, abstract spatial theorizing can be fruitful and logically valid.[4] "Armed with a set of uniformity assumptions,

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[4]Isard, "Regional Science, the Concept of Region, and Regional Structure," p. 14.

one may find it desirable to deny the physical environment of reality and to consider space only in so far as it entails resistance to movement, the so-called friction of distance variable."[5] Although abstraction must of necessity be employed in a theory of local labor market delimitation, it will not be carried to the extreme of completely denying "the physical environment of reality." Such theorizing, by the very nature of the problem, must endeavor to incorporate the space dimension into wage theory. Thus, the theory of local labor market delimitation possesses important implications for wage theory. The second objective is to provide a theoretical framework that will yield some general guide lines for empirical research on commuting patterns.

A hypothesis of this study is that a theory of local labor market delimitation can be developed from economic theory. New analytical tools will be required, but they will be based upon and conform with established economic principles. The introduction of such new tools will represent an extension and not a contradiction of traditional economic principles.

The basic hypothesis of this study is that the geographic limits of a local labor market depend upon the wage, transportation cost and transportation time.

Review of the Literature

The previous quote by Joseph L. Fisher provided a brief historical sketch of theorizing that has endeavored to incorporate space into the description and explanation of economic phenomena. In the literature

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[5]Ibid.

attributable to the authors enumerated by Fisher, there is no rigorous theoretical discussion, within the framework of traditional economic theory, devoted to local labor market delimitation. References to labor markets are frequent. Often however, as typified by Hoover's Chapter 7 entitled Location and the Labor Market, such discussions are in terms of how "locations come to have labor supplies conducive to efficient production."[6] This characteristic is also true of Walter Isard[7] and Alfred Weber.[8] Such discussions do not provide an integrated theory of local labor market delimitation that synthesizes traditional economic theory with the space dimension. Yet if one is to explain, theoretically, how firms come to have adequate supplies of labor it would seem essential to know the geographical extent of the local labor market.

In several of the works of the authors under discussion, the embryo of a theory of local labor market delimitation exists, but in no case is it fully developed to theoretical maturity. For example, Lösch touches upon the problem in the first paragraph of his six page discussion of Wages in Space.[9] He implies in this discussion that the extent of a local labor market, given the wage paid by the firm(s), is some function of "traveling expenses and compensation for time" involved

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[6]Edgar M. Hoover, The Location of Economic Activity (New York, 1948), p. 103.

[7]Walter Isard, Location and Space-Economy (New York, 1956).

[8]Alfred Weber, Theory of the Location of Industries. Carl F. Friedrich. (Chicago, 1929).

[9]August Lösch, The Economics of Location. William H. Woglom. (New Haven, 1954), p. 455.

in such travel.[10] Given the place of employment travel expenses and travel time increase with geographic removal from the place of employment.[11] The discussion is then dismissed with the statement that " . . . the structure of market areas for labor is exactly the same as that for goods and capital."[12] No endeavor is made to integrate these concepts into the existing framework of economic theory in order to explain the delimitation of a local labor market for a given firm or complex of firms. The question that remains unanswered is the identification of the area from which the firm can expect to secure labor, given the place of residence of all individuals. Lloyd G. Reynolds, an author not mentioned by Fisher, touches upon the problem with the following remark: "The findings of this chapter support the impression that the most important boundaries between labor markets run along geographical lines . . . . The labor market is best conceived, then, as an outer circle defined by geography (really, by transportation time and cost rather than distance per se) . . . ."[13] Reynolds does not proceed to develop this proposition analytically. Particular attention is called to that portion of the foregoing quote in parenthesis. The theory of local labor market delimitation, to be developed in the forthcoming chapters, provides a theoretical foundation for this quote.

A concise review of empirical studies on commuting patterns appears in "Labor Market Areas for Manufacturing Plants in West Virginia."[14]

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[10]Ibid. [11]Ibid. [12]Ibid.

[13]Lloyd G. Reynolds, The Structure of Labor Markets Wages and Labor Mobility in Theory and Practice (New York, 1951), pp. 41, 42.

[14]James H. Thompson, Labor Market Areas for Manufacturing Plants in West Virginia, Bureau of Business Research, West Virginia University, December, 1955, pp. 1, 2.

The most comprehensive study to date of employee commuting problems was published in 1955 by the Cornell University Housing Research Center.[1] /"[1]Adams, Leonard P. and Mackesey, Thomas W., Commuting Patterns of Industrial Workers, Cornell University Housing Research Center, 1955."/ The authors, Leonard P. Adams and Thomas W. Mackesey, not only compiled and analyzed primary data showing commuting patterns in several upstate New York communities, but also reviewed the findings of previous studies . . . .

An interesting analysis of commuting trends in a war period was presented in Chapter 7 of a monograph entitled, The Dynamics of Labor Force Expansion, by Herbert S. Parnes of Ohio State University.[2] /"[2]Parnes, Herbert S., A Study in the Dynamics of Local Labor Force Expansion, The Ohio State University Research Foundation, 1951."/ Professor Parnes discussed the changes which occurred in the sources of labor supply for manufacturing establishments in the Columbus, Ohio, area over the period, 1940-1950.

In an article in the November, 1949, issue of Land Economics, J. Douglas Carroll, Jr., discussed type of industry, wage level, size of city, and plant size as factors which may influence commuting patterns.[3] /"[3]Carroll, J. Douglas, Jr., 'Some Aspects of Home-Work Relationships of Industrial Workers,' Land Economics, XXIV, No. 4, November, 1949, pp. 414-422."/ Mr. Carroll's analysis was based upon a large-scale survey conducted in Massachusetts in 1942.

A number of extensive surveys of commuting patterns were made during the early part of World War II. The best known of these surveys was conducted by the Institute of Traffic Engineers and covered 48 war plants. Theodore M. Matson, former Director of the Yale University Bureau for Street Traffic Research, analyzed the results in a publication entitled War Worker Transportation.[4] /"[4]Matson, Theodore M., War Worker Transportation, New York: Institute of Traffic Engineers, 1943."/ Other commuting-distance surveys were conducted during the war period in Indiana, Massachusetts, Michigan, New Jersey, New York, and Ohio. In almost all cases, the purpose of these wartime surveys was to obtain information on transportation and housing needs. Most of the surveys covered large numbers of workers, but the information obtained from each respondent was usually limited to place of residence and method of commuting.

Commuting patterns have been given a prominent place in several studies of regional economies conducted since 1950 by the Bureau of Business Research of the University of Kentucky . . . .[5] /"[5]Martin, James W. and Johnson, John L., 'Labor Market Boundaries--Intercounty Commuting to Employment,' Current Economic Comment, XVII, No. 2, May, 1955, pp. 29-37."/

The sources of labor supply of plants located in rural areas were analyzed in two studies--one by Starnes, Wilkins, and Wisman of the University of Virginia[6] /"[6]Starnes, George T., Wilkins, William M., and Wisman, Paul P., The Labor Force of Two Rural Industrial Plants, University of Virginia, Bureau of Population and Economic Research, 1951."/ and the other by Stepp and Plaxico of Clemson College.[7]

/"[7]Stepp, J. M. and Plaxico, J. S., The Labor Supply of a Rural Industry, South Carolina Agricultural Experiment Station of Clemson Agricultural College, Bulletin 376, 1948."/ Another study, by Glenn H. Beyer of Cornell University, explored the characteristics of rural residents who commuted to work in a large city.[8] /"[8]Beyer, Glenn H., Housing and Journey to Work, Cornell University, Agricultural Experiment Station, Bulletin 877, 1951."/

In addition to these case studies of labor market areas some discussions of a more theoretical character have appeared in books and academic journals. Special mention should be made of Kate K. Liepmann's book . . .[9] /"[9]Liepmann, Kate K., The Journey to Work: Its Significance for Industrial and Community Life, New York: Oxford University Press, 1944."/ and of articles by Leo F. Schnore,[10] /"[10]Schnore, Leo F., 'The Separation of Home and Work, a Problem for Human Ecology,' Social Forces, XXXII, May, 1954, pp. 336-343."/ Donald L. Foley,[11] /"[11]Foley, Donald L., 'Urban Daytime Population: A Field for Demographic-Ecological Analysis,' Social Forces, XXXII, May, 1954, pp. 323-330."/ and William Goldner.[12] /"[12]Goldner, William, 'Spatial and Locational Aspects of Metropolitan Labor Markets,' American Economic Review, XLV, March, 1955, pp. 113-128."/[15]

Mr. Thompson's reference to theoretical discussions does not include any of the names set forth by Fisher as prominent in the field of spatial theorizing. The absence of such names can be interpreted as conforming with the conclusion reached earlier that these individuals did not develop an integrated theory of local labor market delimitation.

A review of empirical studies, as typified, by Thompson's summary, reveals that researchers tend to describe local labor markets in terms of counties or a mileage distance. For example, Adams and Mackesey leaned toward the mileage concept in their study. In turn a commuting study conducted by the Indiana Employment Service utilized the county concept.[16] In this latter study a commuter was defined as any individual living in a county other than the one of employment. In the West

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[15]Ibid.

[16]Indiana Employment Security Division, Indiana State Employment Service, Survey of Commuting Patterns in Selected Indiana Areas, May, 1950.

Virginia study, Thompson utilized both concepts. The Thompson study is also unique, in relation to other empirical studies, in that he uses two measures of the labor market area. "These are the original sources of labor supply (based upon the residential locations of workers when hired) and the present commuting area (based on their places of residence at the time of the survey)."[17] In a study entitled Commuting in the Syracuse Labor Market Area, the authors, Roy Gerard and Allen B. Dikerman, endeavor to depict the dynamic, pulsating nature of a labor market by studying the work force over time.[18]

The Concept of a Local Labor Market

A review of the literature yielded varied definitional concepts of a labor market. Thus the question arises: What is a labor market? "A definition of the term is difficult, and there is no established and popularly accepted concept of the labor market."[19] Part of the difficulty stems from not qualifying or refining the term. It is employed to describe a variety of heterogeneous phenomena. Thus the connotation attached to the term tends to vary among users. There are two general usages of the term local labor market: (1) the geographic area in which an individual can sell his services, and (2) the geographic area from which the firm(s) can draw its labor. Each of these concepts of a labor market in turn is subject to different interpretation

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[17]Thompson, p. 4.

[18]Roy Gerard and Allen B. Dikerman, Commuting in the Syracuse Labor Market Area from the Standpoint of Employment and Unemployment, Business Research Center, Syracuse University, August, 1958.

[19]Dale Yoder and Donald G. Patterson. University of Minnesota. Local Labor Market Research (Minneapolis, 1948), p. 1.

depending upon whether the residential location of individuals is taken as fixed or flexible. Unfortunately, a clear distinction between the foregoing different problems does not appear in the literature. This fact appears to account for the definitional problem.

The empirical studies summarized by Thompson relate to describing the geographic extent of the commuting area with respect to a firm, complex of firms, town or city. Such an area, for purposes of this study, is what the author conceives to be a local labor market. Frequently, however, a local labor market is defined as an area in which workers can and do change jobs without simultaneously altering their place of residence. The reliance on this definition, which is attributable to the War Manpower Commission, accounts for much of the confusion. On the one hand, the empirical researcher frequently falls back upon this definition when confronted with the task of defining the local labor market--despite the fact that it is incompatible with his problem. On the other hand, when the researcher endeavors to depict or approximate the geographic extent of a local labor market he relies upon the residential locations of employed workers at the time of the survey or, as in the case of the Thompson study, also upon their location when hired. The Gerard study of the Syracuse area provides an example.[20] In such instances, the methodological concept and the definitional concept are not compatible.

The methodological concept relates to the geographic area from which a given firm, complex of firms, town or city can expect to draw employees without necessitating workers to alter place of residence;

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[20]Roy Gerard, "The Syracuse Region From the Standpoint of Employment and Unemployment" (unpub. Ph.D. dissertation, The New School for Social Research, 1957), Chapter VI.

whereas the definitional concept relates to the area in which the individual can expect to sell his services without altering place of residence. A rigorous interpretation of the War Manpower Commission definition must of necessity limit the concept to a single individual or at most a group of individuals concentrated in an infinitesimal geographic area. The market area for an individual's services, given place of residence, can encompass portions of two or more local labor markets.

It is now appropriate to set forth the definition of a local labor market as it will be employed in this study. A local labor market is that geographic area from which a firm, complex of firms, town or city draws labor without necessitating workers to alter place of worker residence.[21]

Plan of Presentation

Chapters II, III, and IV will be devoted to introducing, defining and deriving three new analytical tools: the iso-time curve, the net wage function, and the residential preference function. Attention also will be given to demonstrating their compatibility with traditional economic theory. In Chapter V the net wage function and residential preference function will be jointly employed to explain selected problems. Chapter VI will deal with the complexities created by the introduction of adjacent local labor markets and the resulting implications for the net wage function. Thus Chapters II through VI provide the analytical foundation for the theory of local labor market delimitation.

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[21]This definitional concept of a local labor market evolved from the theorizing presented in the chapters to follow. Such theorizing provided the criterion used to evaluate the variety of definitional concepts of a labor market appearing in the literature.

In Chapter VII the delimitation of local labor markets will be undertaken and the conditions for long-run equilibrium derived. Chapter VIII will be devoted to determining whether the equilibrium derived in Chapter VII is stable or unstable. This will be accomplished by disturbing equilibrium and then determining if forces automatically come into play to re-establish long-run local labor market equilibrium. The entire analysis will be conducted under the assumption of pure competition.

CHAPTER II

ISO-TIME CURVES

Definition

An iso-time curve will be broadly defined as the locus of points representing those spatial locations for which travel time is identical with respect to a specified spatial location, given the transportation medium.[1] For local labor market analysis the specified spatial location is the firm or a complex of firms.[2] The relevant other spatial locations for which travel time is identical are the residences of individuals

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[1]Conceptually, an iso-time curve is identical to what Lösch and other German economists referred to as an isochron. The Germans considered the isochron to be circular in shape for an isolated market area, and in the shape of a diamond for towns and cities. In The Economics of Location, Lösch does not use the isochron in conjunction with traditional tools of economic analysis. His reference to it is brief, and then only in connection with street networks (or main traffic lines such as street car routes) as relates to town planning. See: Lösch, pp. 442, 443.

The hyphenation of the term "iso-time" should preclude any possibility of confusing it with Stackelberg's "isotimes" (analogous to both indifference curves and isoquants). See: Heinrich von Stackelberg, The Theory of The Market Economy. Alan T. Peacock (New York, 1952), pp. 107, 108.

[2]At a later stage of analysis the concept of a complex of firms, designated an employment center, will be utilized rather than a single firm. Thus to avoid future definitional inconsistencies this concept is included in the definition of an iso-time curve. The characteristics of an employment center, a complex of firms, are discussed in Chapter VII.

regardless of whether or not they work at the firm or complex of firms. Thus, a given iso-time curve connects those residential spatial locations that are of equal round trip travel time with respect to the firm or a complex of firms, given the transportation medium and the time for beginning and ending work. This latter and more specialized definition of the iso-time curve is utilized in the theory of local labor market delimitation.

Two points warrant special emphasis. First, an iso-time curve represents round trip travel time and not one way travel time. This definitional concept is selected for its methodological advantages. It is more compatible with analytical tools to be introduced in later chapters. Round trip travel time is the summation of travel time incurred during two different periods of the day: (1) that incurred when traveling to work, and (2) that incurred when traveling to place of residence upon the completion of work. The hours of reporting for work and leaving work, which are determined by the firm, are taken as a constant. Thus the iso-time curve employed in the theory of local labor market delimitation is based upon travel time incurred at such specified periods of the day. An iso-time curve derived for any other periods of the day is irrelevant for the theory. It is the travel time incurred in going to and from work that is important.[3] It will be assumed throughout the analysis that round trip travel time divided by two (2) yields one way travel time.

Second, an iso-time curve connects all spatial locations that are

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[3]As will be developed later, an iso-time curve, as broadly defined, is subject to a series of expansions and contractions throughout the day.

of equal round trip travel time with respect to the firm or complex of firms. Theoretically an iso-time curve must not be limited to those individuals currently employed at the firm or complex of firms. The quantitative composition of the labor force will vary with changes in the marginal revenue product of labor, ceteris paribus. Such changes create no problems for the iso-time curve given the second point of emphasis, assuming the resulting increase or decrease in traffic flow is infinitesimal.[4]

Derivation and Characteristics

Because of the strategic analytical role to be assigned iso-time curves in the theory of local labor market delimitation, their derivation and characteristics warrant precise development and explanation. In an endeavor to escape nonessential complexities and thereby accomplish as simply and clearly as possible the task at hand, it will be advantageous to abstract somewhat from reality. Thus in the analysis to follow it is assumed (1) that the medium of transportation used by present and potential employees is the automobile; (2) that these automobiles are uniform in quality, operation, and driving characteristics; (3) that all individuals drive at identical rates of speed under similar highway and traffic conditions, and (4) that individuals act rationally and drive the route that minimizes travel time.[5] The spatial location of all

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[4]As will be shown later, greater than infinitesimal increase or decrease in traffic will tend to alter the shape of an iso-time curve.

[5]The elimination of these assumptions should not preclude the statistical derivation of iso-time curves that are usable in empirical studies of a local labor market. Given a large universe averaging would tend to overcome these problems.

residences is taken as given. Figures 1, 2, 3 and 4 will assist in the discussion to follow.

Derivation of an iso-time curve and its characteristics.--Point A in Figure 1 represents the spatial location of the firm or a complex of firms. The numerous dots represent the spatial location of individual residences. Also shown in the Figure are three major highways designated 1, 2, and 3 respectively. Numerous other streets and roads of varying quality are assumed to exist though not shown. The heavier dots designated B, C, . . . K, each representing a place of residence, are of equal round trip travel time with respect to spatial location A. The curve connecting these dots is an iso-time curve. Any spatial location

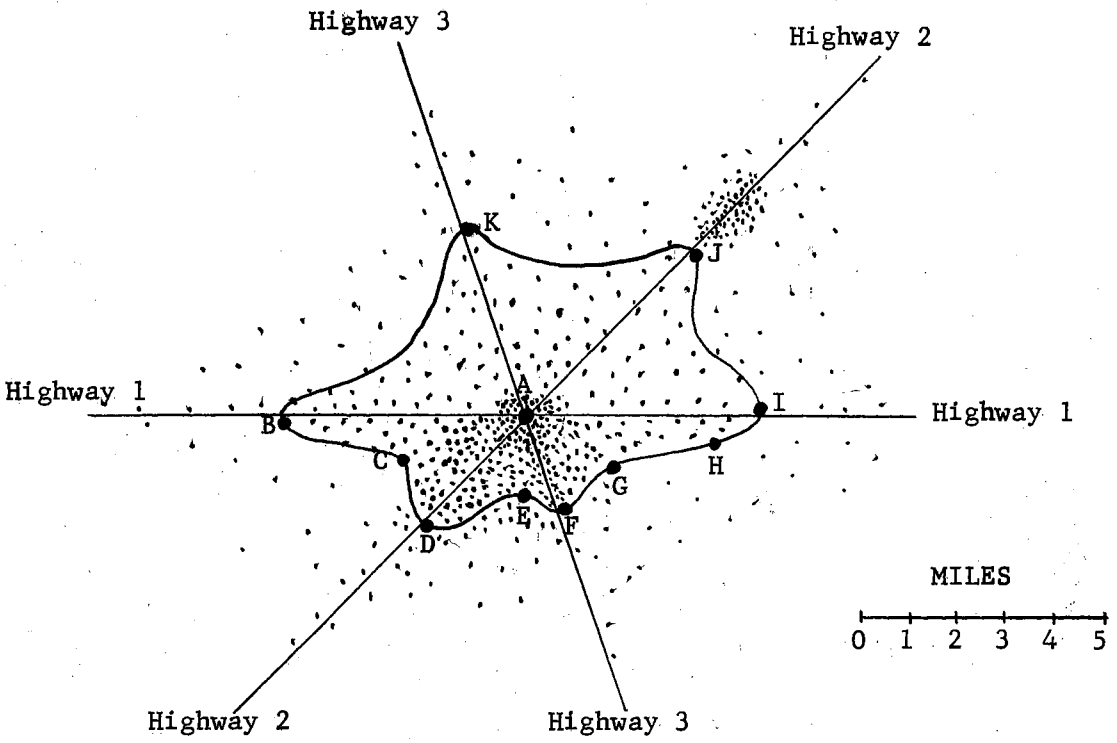

Figure 1

lying on the curve, by definition, requires identical units of travel time to reach spatial location A and return.

An examination of Figure 1 reveals an important characteristic: an iso-time curve need not and probably will not represent equal mileage distances with respect to the firm--either in terms of driving distance given the pattern of highways nor in terms of air miles. This point can be illustrated by constructing a schedule of driving distances for selected spatial locations lying on the iso-time curve shown in Figure 1. Such a schedule is shown in Table 1.

TABLE 1

DRIVING DISTANCES FOR SELECTED INDIVIDUALS THAT RESIDE AT SPATIAL LOCATIONS LYING ON THE ISO-TIME CURVE IN FIGURE 1

Spatial Location of Residence	Driving Distance to Spatial Location A
B	5 miles
C	3 miles
D	3 miles
E	1½ miles
F	2 miles
G	3 miles
H	4 miles
I	5 miles
J	5 miles
K	4 miles

Variations in terrain, the quality and pattern of highway facilities, and traffic congestion are assumed to explain the differences in driving distances for individuals located on the same iso-time curve. For example in Figure 1 it is assumed that highways 1 and 2 are four-lane and divided; whereas highway 3 is two-lane. It is also assumed that the terrain is quite hilly except in the vicinity of highway 3 north of spatial location A where a plain begins. Thus, it takes the worker residing at spatial location K (adjacent to highway 3) the same length of time to drive the four miles as it does the worker residing at

spatial location B (adjacent to highway 1) to drive the five miles, assuming equally dense traffic flows on both highways. Between spatial location B and D, the latter being two miles closer, the equalizer of driving time is attributable to a greater density of population which increases traffic congestion and thus the necessity for impediments to rapid traffic flow, relatively speaking, such as numerous stoplights. An additional explanation also stems from the assumption that highway 2 is more heavily traveled by interstate traffic than highway 1. Excluding interstate traffic, a worker residing at spatial location F encounters similar traffic congestion as the worker residing at spatial location D, but the travel time per mile is greater for the former than the latter due to the assumption that highway 3 is two-lane. The lesser travel time per mile associated with spatial location K versus spatial location F is attributable to variations in terrain and population density: the absence of hilly terrain between residential location K and the firm reduces impediments to passing slow moving vehicles as well as winding roads, and the lower density of population implies less usage of the highway and therefore less traffic congestion. Thus, the shape of an iso-time curve reflects the quality and pattern of highways, terrain, population density and the intensity of traffic flows.

Given the spatial location of the firm and the residence, the foregoing factors constitute the determinants of travel time and can be expressed functionally as follows:

$$TT = \emptyset \ (H, P, T, TF) \tag{2.1}$$

where TT is travel time, H is the pattern and quality of highway facilities, P is population density, T is terrain and TF is traffic

flows (local, intrastate and interstate).[6] In terms of this functional relationship travel time varies inversely with H and directly with P, T, and TF. These directional relationships are illustrated in the above explanation of variations in driving distance between spatial location A (the firm) and residential spatial locations K, B and D respectively of Figure 1. For example, the comparison of spatial locations K and B illustrates the inverse relationship between travel time (TT) and the pattern and quality of highway facilities (H); the comparison of spatial locations B and D illustrates the direct relationship between travel time and population density (P) and traffic flow (TF); the comparison of spatial locations K and F illustrates the direct relationship between travel time and terrain (T) as well as population density.

Since one of the determinants of travel time is traffic flow, travel time will vary throughout the day. During peak flows of traffic, travel time will be greater than during off-peak periods. Thus an iso-time curve is subject to a series of expansions and contractions throughout any given day. This phenomena does not invalidate the use of the iso-time curve in the theory of local labor market delimitation. The time of starting and ending work each day is taken as a constant, and it is for these two time periods that the round trip travel time is computed. An iso-time curve derived for any other time period is irrelevant. In the theory of local labor market delimitation, the problem is to derive travel time associated with the sale of labor services to the firm for a specified period of time. The time dimension of the

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[6]Given the spatial location of the residence and the firm, driving distance is taken into account through the variable H, since driving distance between two points is a function of the pattern of highway facilities.

labor market, the hours during which labor services are demanded, is established by the firm. It is of no consequence that round trip travel time is greater or smaller for other periods of the day. For such periods do not conform with the time dimension of the given labor market. It is for this reason that the definition of an iso-time curve for purposes of the theory of local labor market delimitation includes as a given "the time for beginning and ending work."

The iso-time curve depicted in Figure 1 is continuous. This representation must not be construed as portraying continuity as a characteristic of an iso-time curve. Given the existence of certain terrain features such as rivers and mountains an iso-time curve can be discontinuous. Occurances of discontinuity in an iso-time curve will be treated in the forthcoming discussion of a system of iso-time curves. Therefore it is now appropriate to merely set forth the following as an important characteristic: An iso-time curve can be discontinuous.

A system of iso-time curves.--The system of iso-time curves for the firm or complex of firms that will be depicted initially rests upon a simplifying assumption concerning terrain barriers. The existence of terrain barriers that result in (1) discontinuous iso-time curves and (2) isolated "pockets" of iso-time curves, are assumed away. However, before leaving the sub-section under discussion, this simplifying assumption will be removed in order to examine its implications for a system of iso-time curves.

Based upon the foregoing assumption, Figure 2 represents a system of iso-time curves for the firm or complex of firms. As one moves outward from spatial location A in any direction the units of travel time

represented by each successive iso-time curve increases.[7] Thus iso-time curves are designated numerically outward as follows: 1, 2, 3, 4, 5, 6, and so on. The travel time represented by the iso-time curve designated 4 is less than the travel time represented by the iso-time curve designated 5. In turn iso-time curve 5 represents a smaller amount of travel time than curve 6 and so on. Theoretically, iso-time curves can be

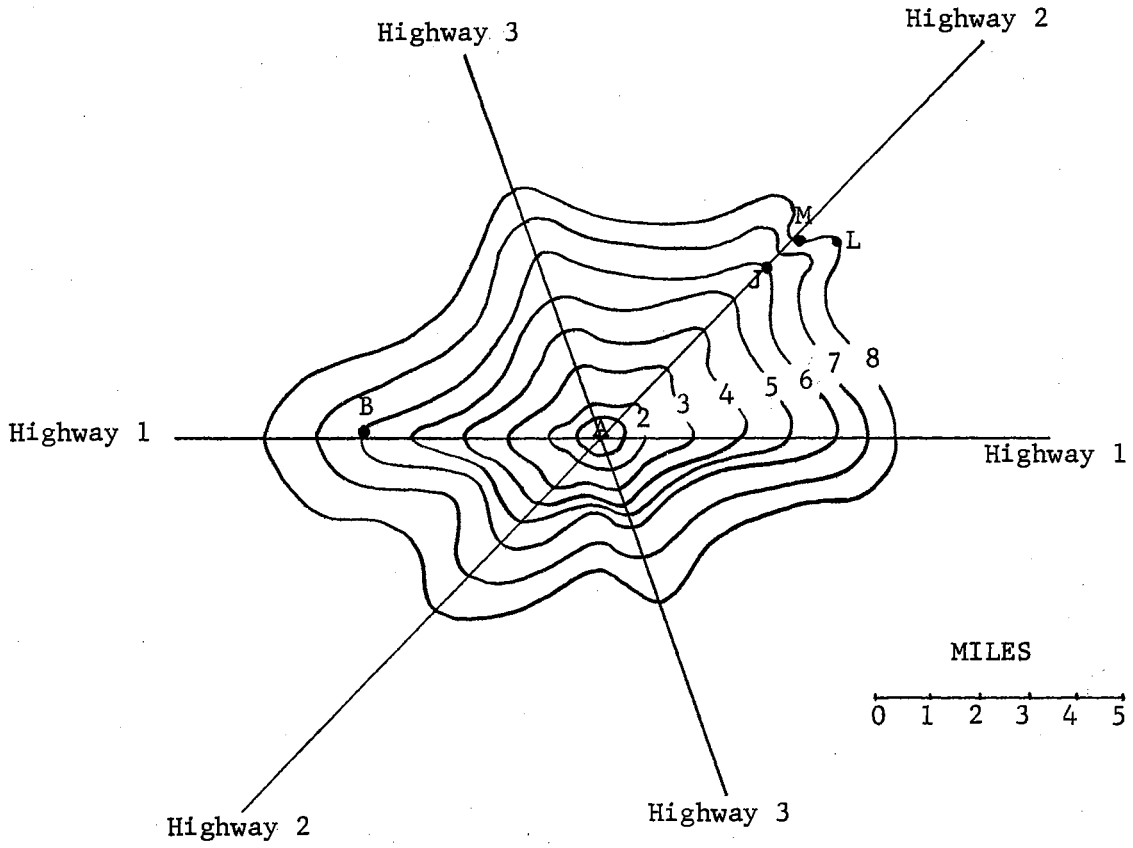

Figure 2

infinitesimally close together. As will be demonstrated later, this does not mean that the units of travel time between two such curves is

[7]With the introduction of terrain barriers exceptions to this proposition occur. As will be shown, there may be occasions where an iso-time curve further removed from the firm actually yields a smaller travel time.

necessarily infinitesimal. Curve 6 in Figure 2 is the iso-time curve derived in Figure 1. Points B and J are shown merely to assist in identification of the curve.

The "camel-hump" in iso-time curves 7 and 8 in the vicinity of highway 2 (northeast portion of diagram) warrants brief explanation. It depicts a situation where traffic flow is slowed down as a result of numerous stoplights and heavy local traffic such as might be encountered in a small suburban area, shopping center, or small town. Thus workers residing in adjacent areas may circumvent this traffic congestion and thereby reduce travel time by driving on secondary streets or roads for some distance prior to entering highway 2 at the appropriate spatial point between iso-time curves 6 and 7.[8]

It is now appropriate to remove the simplifying assumption underlying the system of iso-time curves shown in Figure 2. Figure 4 depicts a system of iso-time curves for the firm or complex of firms, represented by spatial location A, where the existence of terrain barriers preclude some iso-time curves from being continuous. The river, in the upper

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[8]Individual 1 residing at spatial location L, despite a greater driving distance, lies on the same iso-time curve as individual 2 residing at spatial location M. For by driving on a suburban thru street paralleling highway 2 for some distance, individual 1 avoids the traffic congestion, increases his miles driven per unit of travel time in the relevant spatial area, and thereby reduces to a minimum his aggregate travel time to and from the firm. In turn individual 2 finds that the route yielding the minimum travel time to and from the firm is on highway 2 through the congested area. Two factors account for this phenomena: (1) to take the suburban route would result in individual 2 driving a greater rather than a smaller mileage than individual 1, and (2) individual 2 would still have to drive out of the congested area to reach the suburban thru street in question--thus within some range mileage per unit of travel time will not increase and may actually decrease as the secondary streets used are assumed to be two-lane and not four-lane.

portion of the figure, and a canyon, located directly west of the firm between the 10 minute and 30 minute iso-time curves, constitute two such terrain barriers. The task at hand is to determine the effects of these barriers upon a system of iso-time curves. Each terrain feature will be treated individually. The iso-time curves of Figure 4 have been assigned time values, rather than chronological numerical designations, to facilitate the analysis. Such values represent round trip travel time. The highway system south of the river is assumed to consist of a network of paved east-west and north-south streets similar to that found in an average city. North of the river, however, the network of streets consist of two paved roads running directly north from the two bridges and one paralleling the river. The remainder of the roads north of the river are assumed to be of gravel or dirt composition and of a non-uniform pattern.

Prior to examining the effects of terrain barriers upon a system of iso-time curves, the implications associated with one of the foregoing assumptions merits discussion. Since the highway system south of the river in Figure 4 is assumed to consist of a network of paved east-west and north-south streets similar to that found in an average city, the iso-time curves will tend to take the shape of a diamond, as indicated by Lösch's discussion of isochrons for a town.[9] Figure 3 provides an illustration. The following assumptions govern Figure 3: the terrain is a perfectly flat plain; population density, traffic flow and the quality of highways are identical. Given these assumptions travel time varies directly and proportionally with distance. The equal squares

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[9]Lösch, p. 443.

formed by the streets provide a convenient means for verifying that any point on a given iso-time curve in Figure 3 is equidistant and thus of

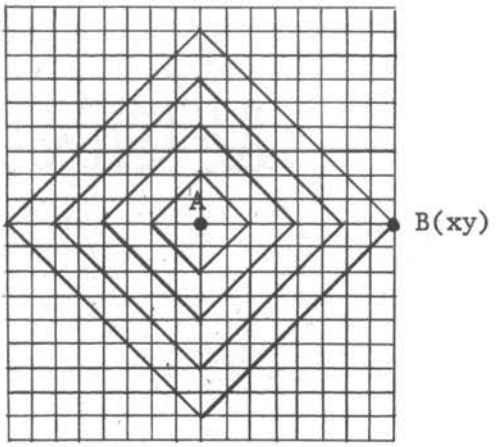

Figure 3

an equitime with respect to location A($x + y$ = constant, for any given curve). The iso-time curves south of the river in Figure 4 do not conform precisely to the diamond shape described above. This is assumed to be explainable in terms of variation in traffic flows and population density.

The effects attributable to the river will be examined first. An individual residing at spatial location C, adjacent to the south bank of the river, is on the 20 minute iso-time curve. However, if the individual resided at spatial location D, adjacent to the north bank of the river, his round trip travel time would be 60 minutes. The difference in travel time of 40 minutes is due to the location of the two bridges (designated B_1 and B_2) spanning the river. Thus spatial locations C and D provide an illustration of the case where two adjacent iso-time curves though relatively close to one another represent significantly different travel times. An examination of the 30 minute

iso-time curve reveals that it fails to extend northward to either spatial location E or F, both of which are located adjacent to the south bank of the river. Further examination reveals that a 30 minute iso-time curve does not reappear to the north of the river. This phenomenon logically follows from the fact that the minimum travel time for any location north of the river is slightly more than forty minutes, as represented by locations in the vicinity of the north end of the two bridges. The 30 minute iso-time curve is discontinuous at points E and F. The foregoing discussion also applies to the 40 minute iso-time curve. Although there is a 50 minute iso-time curve north of the river it is not connected with the 50 minute iso-time curve south of the river. Further, the spatial location adjacent to the south bank of the river and lying on the 50 minute iso-time curve, point H, is further west than its spatial counterpart, point G, on the 50 minute iso-time curve lying north of the river. Two factors explain why location G lies further east than location H even though both are of equitravel time with respect to the firm: (1) to compensate for the driving distance associated with crossing the river, and (2) increased traffic congestion in the vicinity of bridge B_2. Thus even though the 50 minute iso-time curve appears both north and south of the river, it too is discontinuous.

The isolated pocket of iso-time curves located to the west of the firm, between the 10 minute and 30 minute iso-time curves, is attributable to the existence of a canyon. Although several roads are assumed to provide access to and from the canyon, all such routes are restricted to the canyon's west wall by assumption. Before proceeding further it should be noted that the existence of the canyon causes the 20 minute iso-time curve to be discontinuous at spatial locations I and J. The

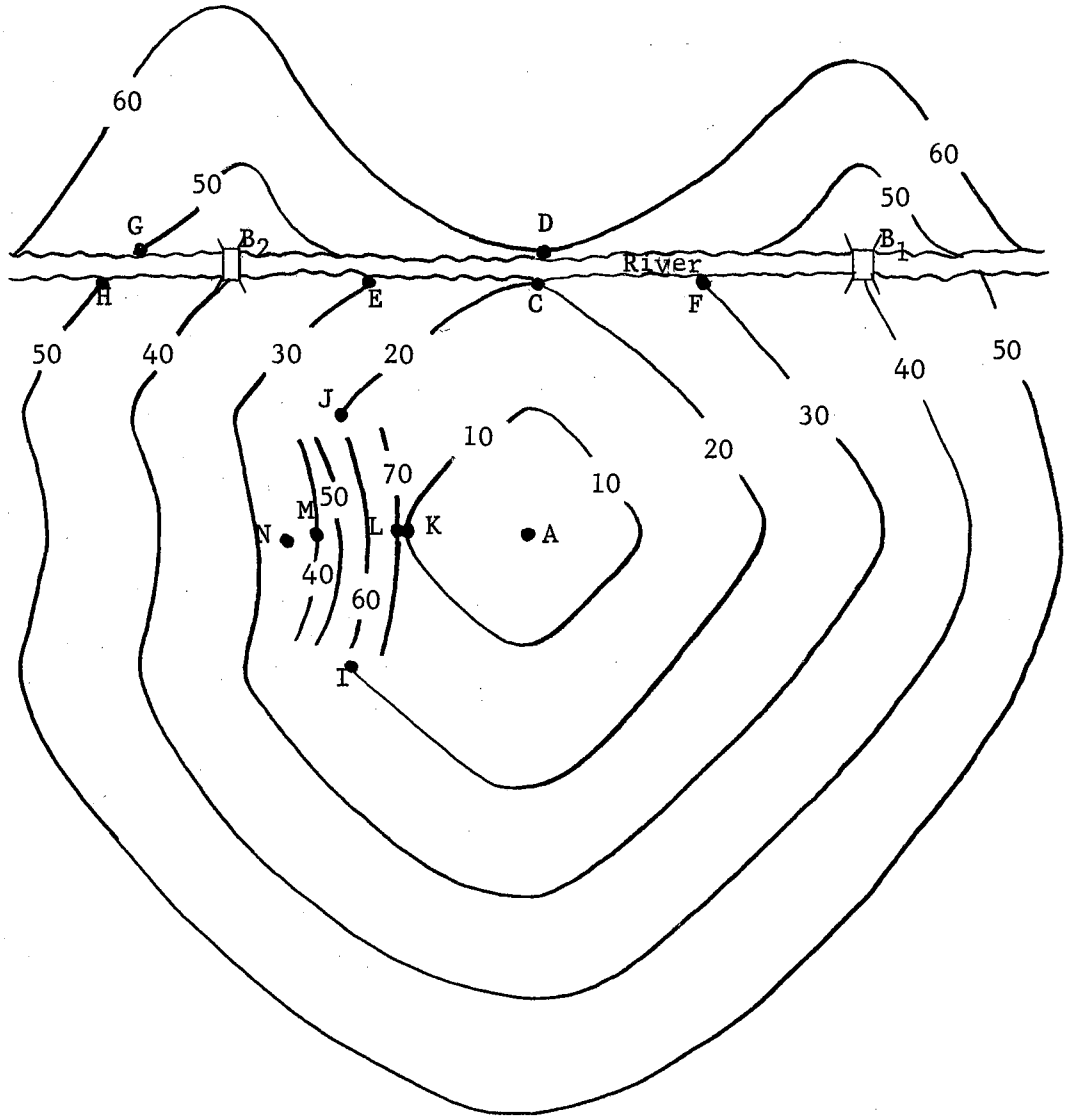

Figure 4

introduction of the canyon illustrates once again that two adjacent iso-time curves though infinitesimally close together can represent significantly different travel times. For example, residential location K, located on the east rim of the canyon, is on the 10 minute iso-time curve; whereas residential location L, directly adjacent to K but on the canyon floor, is on a 70 minute iso-time curve. This phenomenon conforms with the earlier statement that an iso-time curve need not be separated by infinitesimal differences in travel time. Such pockets of

iso-time curves also tell one that each successive move outward from the firm need not always result in increased travel time. For example, a move from residential location M to N results in a decrease of travel time from forty minutes to approximately twenty-six minutes. The convexity of the 30 minute and 40 minute iso-time curves with respect to the firm and west of the canyon reflect the fact that individuals in that area are required to drive around the canyon in order to reach the firm.

The foregoing discussion indicates that the introduction of terrain barriers introduce new complexities for a system of iso-time curves. These new complexities can be summarized as follows: (1) an iso-time curve can be discontinuous; (2) although two iso-time curves can be infinitesimally close together, they can represent significant differences in travel time; and (3) it is possible to have isolated pockets of iso-time curves. This latter complexity in turn gives rise to a situation where by moving outward from the firm in a straight line a spatial location might be encountered that yields a smaller travel time than one lying between it and the firm. It should also be recognized that terrain barriers can be man made as well as natural. Thus, discontinuity of iso-time curves can be expected as a result of large man made lakes, large private or public installations, canals and airports as well as mountains, canyons, rivers and swamps.

Characteristics of iso-time curves.--It is now appropriate to briefly summarize the key characteristics of iso-time curves. First, iso-time curves need not be continuous. They can be either continuous or discontinuous. Second, iso-time curves need not and probably will not connect spatial locations of equal highway distance with respect to

the firm or complex of firms. Thus in those instances where iso-time curves are continuous, they need not and probably will not take the form of a circle about the firm or complex of firms. Third, iso-time curves need not be parallel to each other. They may or may not be parallel. Fourth, an iso-time curve that is continuous need not connect all spatial locations that are of equal travel time with respect to the firm. Given the existence of certain terrain barriers, it is possible to have one or more isolated pockets of iso-time curves. In such instances movement outward from the firm in a given direction can yield smaller rather than larger travel times for some geographic distance. Fifth, theoretically iso-time curves will normally lie very close to one another; however, the travel time represented by two adjacent curves can be either infinitesimally or significantly different depending upon the terrain. Sixth, iso-time curves for a given firm or complex of firms by definition, cannot intersect.[10] If iso-time curves intersected, this would imply that a spatial location had two minimum travel times with respect to the same firm or complex of firms, which is nonsense. For any given spatial location there can be only one minimum travel time with respect to a given firm or complex of firms. This characteristic does not preclude iso-time curves of different systems from intersecting. It applies only to the iso-time curves comprising one system--those representing a single firm or a single complex of firms. These characteristics are explainable in terms of the earlier conclusion that travel time and thus the shape of iso-time curves are a function of the quality

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[10]The travel times used in the derivation of iso-time curves are for those routes that minimize travel time from the place of residence to the firm. See assumption 4, page 15.

and pattern of highway facilities, population density, terrain and the intensity of traffic flows (local, intrastate and interstate).[11]

For purposes of simplicity, the existence of terrain barriers that result in discontinuous iso-time curves or isolated pockets of iso-time curves are assumed to be nonexistent in the chapters to follow. Thus all systems of iso-time curves used in the forthcoming chapters will take the general form of the system depicted in Figure 2. This procedure will facilitate the identification of key variables and their direction of movement in the analyses to follow. However, it is advantageous to recognize at all times the existence of this simplifying assumption as well as its implications for a system of iso-time curves. The foregoing discussion of terrain barriers and the explicit statement of this simplifying assumption stem from a desire to achieve this recognition.

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[11]This functional relationship is in accord with the initial assumption that workers travel to and from work only by automobiles. It should be recognized that the determinants of travel time will vary with the transportation medium. Thus if it is assumed that workers walk to work, as might well be typical in an underdeveloped economy, then travel time is a function of terrain and the pattern and quality of footpaths, trails or roads assuming away differences in individual physical abilities.

CHAPTER III

THE NET WAGE AND THE NET WAGE FUNCTION

The net wage function is an important analytical tool for the theory of local labor market delimitation. Later it will be utilized to identify spatial locations that delimit one local labor market from another. (As will be shown, a worker residing at such a spatial location would be indifferent between employment in either local labor market.) By repeating the process for an infinite number of spatial locations a locus of points will be generated that delimits local labor markets. Thus via the use of the net wage function, a logical foundation will be provided for a conclusion concerning a necessary but not sufficient condition for long-run local labor market equilibrium expressed in terms of iso-time curves.[1] Further, when long-run local labor market equilibrium is disturbed the net wage function will assist in identifying those variables, and their direction of movement, that automatically come into play to re-establish equilibrium. This tool also enables one

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[1]The necessary but not sufficient condition for long-run local labor market equilibrium is as follows: the curve delimiting local labor markets represents the points of tangency and intersection of equal iso-time curves. This condition is explained in Chapter VII. This does not conflict with the nonintersecting characteristic of an iso-time curve. This latter characteristic refers to a simple system of iso-time curves; whereas the foregoing condition refers to the intersection of curves in different systems. See item 6, page 28.

to identify, at any given instant, spatial locations that form the boundary line between local labor markets during the transition period--that is while moving from one equilibrium to another. Thus the net wage function provides a tool for period analysis. For these reasons the concept of a net wage function merits careful development. Figures 5, 6, 7 and 8 later will assist in this endeavor.

The Net Wage

Defined.--The first task is to set forth a definition of the term, net wage. For purposes of this study, an individual's net wage will be defined as, the wage paid by the firm less those net costs incurred by the employee in traveling to and from work as a direct result of residing at a given spatial location, per unit of time.[2] This definition can be expressed algebraically as follows:

$$W_n = W - C_n \tag{3.1}$$

where W_n is the net wage, W is the wage paid by the firm which is equal to the value of marginal product of labor assuming pure competition, and C_n is the net cost incurred by the worker in traveling to and from work per unit of time. In the discussion to follow the "per unit of time" is assumed to be one day. Thus the daily wage of labor minus net costs incurred in traveling to and from work equals the daily net wage of the employee.

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[2]This analysis deals with only one aspect of that broader segment of economic theory devoted to equalizing and nonequalizing differences in wages. Beside the disutility associated with travel time there are numerous other disutilities such as risks on the job, unpleasantness of working conditions (physical and human) as well as off-the-job disutilities such as local taxes and unfavorable climate. These other disutilities are excluded from consideration in this study.

Two important relationships are deducible from the foregoing equation. As the value of marginal product of labor increases, and thus the wage paid by the firm, the net wage rises, ceteris paribus. In turn the smaller the value of marginal product of labor the smaller the net wage, ceteris paribus. Thus, the net wage varies directly with the value of marginal product of labor. On the other hand the functional relationship between the net wage and net costs is an inverse one. A rise in net costs, ceteris paribus, causes a fall in the net wage. In turn a fall in net costs, ceteris paribus, causes a rise in the net wage.

The determinants of net costs (C_n).--Attention is now turned to the determinants of C_n in equation (3.1). Only when the term net cost is accorded precise meaning does the foregoing definition of the net wage become a usable concept for the theory of local labor market delimitation. The cost directly incurred in traveling from place of residence to place of employment and back again, given the transportation medium, is not necessarily a net cost figure, and therefore not always the appropriate figure for determination of the net wage.[3] Other relevant factors that must be taken into account include: (1) variations, if any, in the cost of living within the spatial area under study, and (2) the propinquity of residence to alternative employment opportunities.

The effect upon the net wage of differences in the cost of living between various spatial locations, working through C_n, can be illustrated by a hypothetical case. A worker is in the process of moving into a given local labor market. He desires to live in a rural area. Given

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[3]In accord with an earlier assumption that workers travel to work only by automobile, the cost directly incurred in traveling from place of residence to place of employment and back again would include gasoline, oil, and depreciation.

his tastes and preferences for housing he finds two residences that satisfy him equally. However, residence 1 is located closer to his new place of employment than residence 2. Thus in terms of travel cost to and from the firm, residence 1 will necessitate less expense, assuming uniformity in driving conditions for both residences. On further investigation, however, he finds the cost of living substantially higher at residence 1. After careful calculation it is determined that the lower cost of living at residence 2 is not only sufficient to offset his extra travel expenses but also sufficient to compensate him for the substitution of driving time for leisure time and still leave him with a slightly higher net wage. Therefore to maximize his satisfaction he selects residence 2. Thus to determine the net wage a worker in computing net costs of travel would take into account not only his travel costs but also differences in the cost of living.

In the theory of local labor market delimitation, it will be assumed that the cost of living is identical for all relevant spatial locations. This assumption does not appear to depart significantly from reality in view of the relatively limited geographical extent of individual local labor markets. However, there are distinct advantages to be gained from recognizing that variations in the cost of living can affect the determination of net costs and therefore the net wage. The foregoing discussion and assumption stem from a desire to achieve this recognition.[4]

The propinquity of alternative employment opportunities as a determinant of net costs and in turn the net wage will be treated analytically

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[4]Variations in the cost of living arising from complete utilization of a given spatial area receive special treatment in Chapter V.

in a later discussion of the net wage function. For the present it will suffice to say that this variable influences the determination of net costs incurred by working at one firm only when the worker resides at a spatial location that in terms of travel time is closer to another firm. Given the worker's place of residence, so long as he lives closer to the firm of employment than any other firm in terms of travel time, this variable does not enter into the computation of net costs. However, when the worker resides at a spatial location that is closer in terms of travel time to some other firm than the one at which he is working, then in computing his net costs he will take into account the extra driving time involved. The leisure time given up to work at the one firm represents a cost that can be avoided by working at the closer firm.[5]

Assuming the cost of living to be identical for all relevant spatial locations, net cost will be defined to include: (1) the costs of traveling to and from work given the transportation medium, and (2) the difference in opportunity costs of travel time associated with the place of employment and the firm nearest the spatial location of the residence. So long as the spatial location of a worker's residence is closer in terms of travel time to his place of employment than alternative

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[5]Assume a worker is within commuting distance of two different firms and that one is currently offering a higher wage (which indicates that long-run equilibrium does not prevail). Given his current place of residence, he may find that (in the short run) he will maximize his net wage by working at the firm offering a lower wage. For the additional income earned by working for the firm offering the higher wage, though equal to or slightly greater than the addition to travel costs, would not be sufficient to offset the increased travel time necessitated by such employment. That is, his daily net wage would be less than in the alternative employment when the additional travel time required is taken into account.

places of employment, the wage paid by the firm less travel expenses yields the net wage. However, if the spatial location of the worker's residence is closer to a firm other than the one affording him employment, then in deriving the net wage he will also include as a part of net cost that amount of travel time that could be eliminated by employment at the nearest firm.

The Net Wage Function

A basic assumption.--The concept of the net wage function rests upon the assumption that travel costs between place of residence and place of employment, given the transportation medium, vary directly with travel time. This assumption is supported by general observation. Its validity rests upon an appeal to experience.[6] It appears to conform with reality. An appreciation of this position may be facilitated by two hypothetical illustrations. In both, the automobile is assumed to be the medium of transportation.

First take a simplified case where the quality of highways and traffic congestion are identical throughout a given area. Then it is obvious that given a greater travel time the greater will be the costs of traveling to and from work for a given individual. In such a case the mileage driven increases proportionately with travel time. However, when the individual encounters variations in the quality of highways and traffic congestion, the second and more complicated case which conforms with reality, travel time and mileage driven diverge. The

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[6]For a discussion of assumptions or principles used in economic theory that rest upon an appeal to experience see: J. R. Hicks, Value and Capital, Second Edition, (Oxford at The Clarendon Press, 1946), pp. 22, 23.

assumption under discussion implies that when this occurs travel time affords the individual a more appropriate measure of travel costs than does mileage driven.

Two spatial locations may involve identical driving time and therefore identical travel costs although the actual mileage distance of each with respect to the firm is quite different. This is illustrated by the following hypothetical case involving two residential locations identified as A and B. At spatial location A the individual would be required to drive 5 miles through heavy traffic congestion to reach the firm. The congested traffic conditions require continuous starting and stopping, accelerating and decelerating, and standing still for short periods of time with the automobile idling. Such driving conditions increase gasoline consumption as well as wear and tear on brakelining, tires, and other mechanical components of the automobile. On the other hand at spatial location B the individual drives 10 miles on a standard highway through uncongested rural areas at a relatively constant rate of speed. He is not subject to numerous starts and stops until within close proximity of the firm. Thus the individual finds that the per mile costs of driving from spatial location A to the firm are greater than those associated with spatial location B. In the aggregate the total costs of travel tend to be approximately the same for both spatial locations. The fact that gasoline mileage checks yield different results for in-city driving versus highway-driving provides further support for the assumption.

Derivation.--The net wage function depicts the relationship between the net wage and travel time for a given vector given the value of marginal product of labor and the strength and pattern of workers'

tastes and preferences for their current place of residence. (A vector is defined as a curve moving outward from the firm. The concept of a vector receives detailed treatment at a later stage of analysis.) The net wage varies inversely with travel time. This inverse relationship and the derivation of a graph of the net wage function for a single firm, or complex of firms, will be illustrated with the aid of Figures 5 and 6.

Before proceeding further it is necessary to set forth the items measured on the x and y axes of a net wage function diagram (as typified by Figures 5 and 6). The vertical axis represents dollars. It is used to measure both the wage paid by the firm and the net wage of individuals working at the firm. The horizontal axis represents travel time (designated TT). More specifically the horizontal axis is used to locate the residence of workers with respect to place of employment, the firm, in terms of daily round trip travel time. Such travel time is based upon the route yielding the minimum time.[7] The intersection of the vertical and horizontal axes, where travel time is zero, represents the location of the firm. Travel time increases positively along the horizontal axis as one moves either rightward or leftward from the firm.

Assume that employment opportunities are available at only one firm (firm 1 in Figure 5) and that the wage paid is W_{10} (where W_{10} = VMP of labor). Now if an individual worker lived infinitesimally close to the firm, in terms of travel time, then his net wage would be W_{10}. Point A in Figure 5 represents such a situation. Only in those instances where net costs equal zero, as typified by point A, will the

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[7]See assumption 4, page 15.

net wage equal the value of marginal product of labor.[8] However, a worker residing at the spatial location represented by TT_1 units of travel time (round trip) will incur some travel expenses in going to and from work. Therefore his net wage will be less than W_{10}. By subtracting the travel expenses associated with travel time TT_1 from the wage W_{10}, the net wage for the worker(s) residing at such a spatial location is derived. Let W_9 represent the net wage derived. This situation is depicted by point B in Figure 5. In turn a worker residing

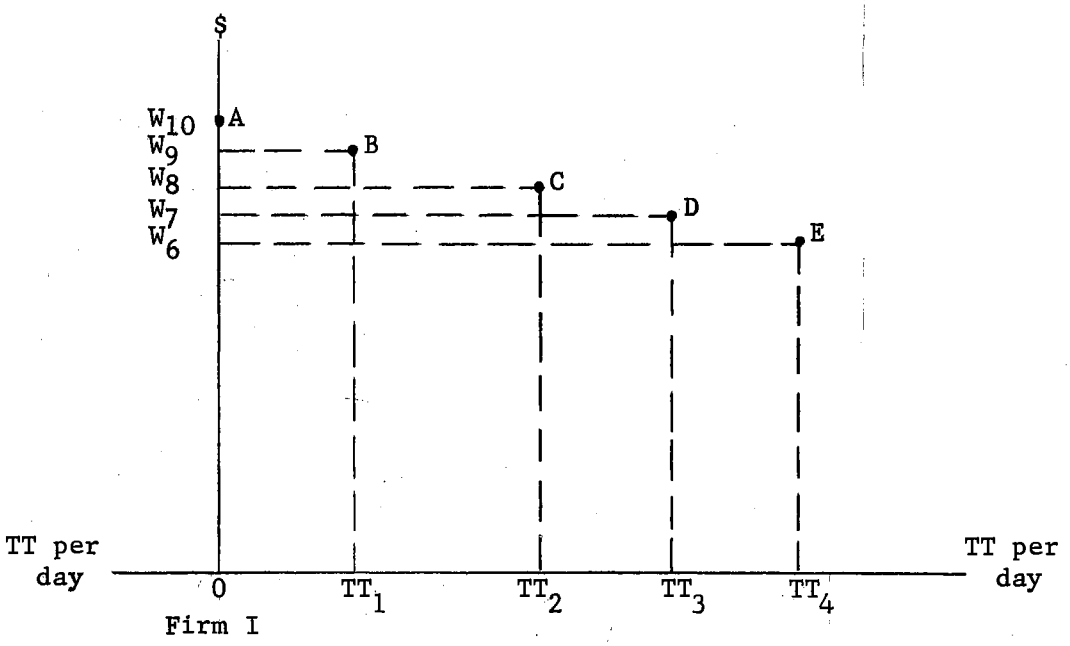

Figure 5

at the spatial location represented by TT_2 units of travel time will

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[8]This can be illustrated by employing the algebraic definition of the net wage (3.1):

$$W_n = W_{10} - C_n$$
$$\text{if } C_n = 0$$
$$\text{then } W_n = W_{10}$$
$$\text{Since by definition } W_{10} = VMP_L$$
$$\therefore W_n = VMP_L.$$

incur travel expenses that exceed those associated with TT_1. Point C depicts this situation. The foregoing conforms with the assumption that travel costs vary directly with travel time. Thus, the greater the travel time, the greater the travel costs and the smaller the net wage. Points D and E represent the net wage received by workers residing at spatial locations TT_3 and TT_4 respectively. Points A, B, C, D, and E in Figure 5 depict graphically the inverse relationship between the net wage and travel time. This relationship is also shown in Table 2. By a similar process points depicting the relationship between travel times, to the left of firm I, and the net wage can be derived.

TABLE 2

A HYPOTHETICAL NET WAGE SCHEDULE

Worker	Worker's Residence With Respect to Firm in Terms of Round Trip Travel Time	Wage Paid By The Firm	Net Wage ($W_n = W - C_n$)
1	0	W_{10}	W_{10}
2	TT_1	W_{10}	W_9
3	TT_2	W_{10}	W_8
4	TT_3	W_{10}	W_7
5	TT_4	W_{10}	W_6

By repeating the foregoing process for an infinite number of travel times a locus of points is generated similar to that shown in Figure 6.[9] This curve represents a plot of a net wage function for firm I and its local labor market, assuming away contiguous local labor markets. (This

[9]For purposes of simplicity, the form of the net wage function is assumed to be linear in this study. In reality, however, it might be non-linear.

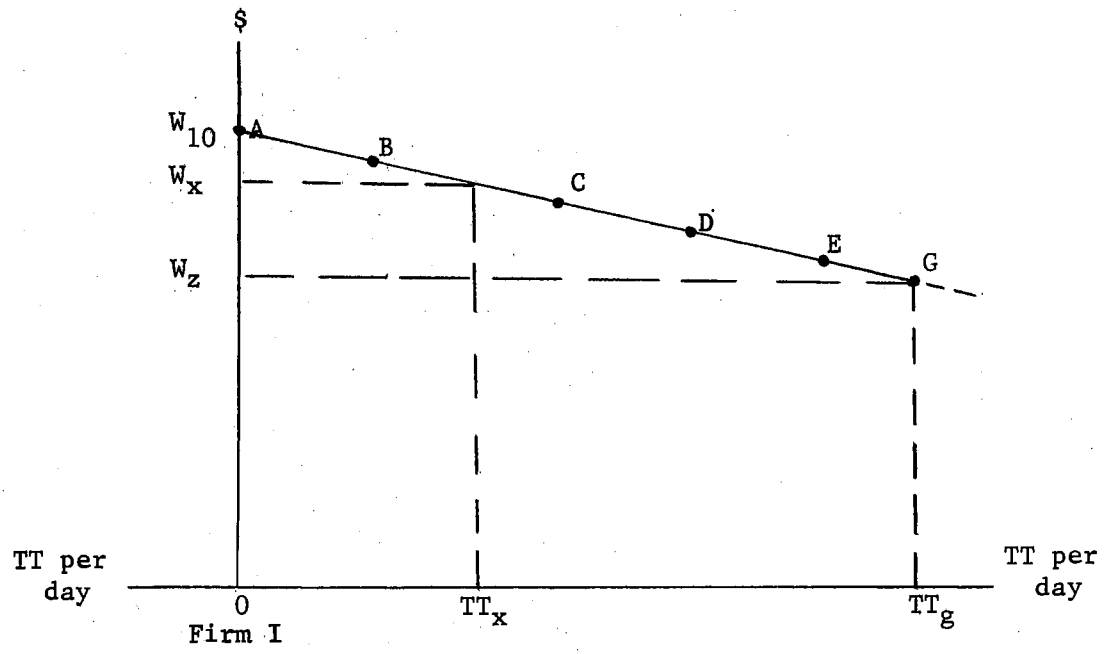

Figure 6

last assumption will be removed at a later stage of analysis. The introduction of contiguous local labor markets will result in a change in the slope of the curve beyond some point.) Given the wage paid by the firm, the net wage function shows what the workers net wage will be for any given residential spatial location as represented by travel time. For example a worker residing at TT_x in Figure 6 will have a net wage of W_x. The function depicts the relationship between the net wage and travel time.

The foregoing discussion of the net wage function, assuming no contiguous local labor markets, can be briefly summarized in terms of simple mathematics. The equations of the system are

(3.2) $$W_n = F(W, C_n)$$

(3.3) $$W = \alpha(MPP_L, P_x)$$

(3.4) $$C_n = \beta(TT)$$

(3.5) (2.1) $$TT = \phi(H, P, T, TF).$$

The symbols have the following meaning: W_n, net wage; W, the wage paid by the firm; C_n, net costs; MPP_L, the marginal physical product of labor; P_X, the per unit price of the goods or services produced; TT, round trip travel time; H, the pattern and quality of highway facilities; P, population density; T, terrain; TF, traffic flows. Of the foregoing variables, the following are regarded as given: MPP_L, P_X, H, P, T and TF.

The form of the equation representing the net wage function will now be derived. As previously stated the definition for the net wage is (3.1):

$$W_n = W - C_n \qquad C_n \geq 0.$$

Assuming no contiguous local labor markets, net costs are identical to travel cost by definition, given the automobile as the medium of transportation. Travel cost is a function of round trip travel time between place of residence and place of employment. Thus the equation of net costs takes the form:

(3.6) $$C_n = b(TT) \qquad b>0$$

where b represents the unit cost of travel time.[10] From equations (3.1)

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[10] Since this equation is assumed to be linear (which by definition means the net wage function is linear), each per unit increase in travel time will involve a constant increase in net costs. Thus if travel time increases from TT to $TT + \Delta TT$, net costs will rise from C_n to $C_n + \Delta C_n$. Using equation (3.6), it is found that

$$C_n + \Delta C_n = b(TT + \Delta TT)$$
$$= bTT + b\Delta TT.$$

Subtracting equation (3.6)

$$\Delta C_n = b(\Delta TT).$$

By transposing,

$$b = \frac{\Delta C_n}{\Delta TT}.$$

Thus, b represents the unit cost of travel time. In familiar terms, b is the slope of the curve depicting the net cost function.

and (3.6) the net wage equation assumes the following form:

$$W_n = W - b(TT). \tag{3.7}$$

Since the determinants of travel time are taken as given, travel time for alternative spatial locations is regarded as given. Thus for spatial location A

$$TT_a = TT_1 \tag{3.8}$$

where the subscript for the left side of the equation indicates the spatial location, and the right hand side of the equation depicts the given travel time for that location. Since the value of marginal product of labor ($MPP_L \cdot P_x$) is taken as given, the wage is regarded as a given. Thus

$$W = W_o \ . \tag{3.9}$$

From equations (3.7), (3.8) and (3.9) the net wage equation for spatial location A is

$$W_n = W_o - b(TT_1). \tag{3.10}$$

Thus, equation (3.10) represents the net wage for spatial location A which has a round trip travel time with respect to the firm of TT_1. By inserting in (3.10) the travel time for alternative spatial locations on the given vector (defined as a curve moving outward from the firm), the net wage associated with each of the locations is derived. From the results so obtained, a graph of the net wage function can be drawn. Its appearance will be similar to the curve depicted in Figure 6.[11]

The graph of the net wage function shown in Figure 6 is based upon

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[11]The net cost curve slopes upward and to the right, as indicated by equation (3.6). The net wage curve slopes downward and to the right, as indicated by equation (3.7). Thus for any given travel time the difference between the wage paid by the firm and the net wage is equal to net costs. In terms of equation (3.1): $C_n = W - W_n$.

the assumption that the spatial location of the firm is fixed--being represented by the intersection of the x and y axes. A graph of the net wage function can also be constructed upon the assumption that the spatial location of the firm is variable in relation to a given individual's residence. In such a diagram the intersection of the x and y axes represents the spatial location of the residence. Thus travel time depicts alternative locations of the firm with respect to the fixed location of the residence. A continual recognition of these two alternatives for the labeling of the x and y intercept is imperative. A failure to distinguish between the two alternatives can lead to future misapplication of analytical tools. For example in combining a graph of the net wage function with a graph of the residential preference function (a concept to be developed) in Chapter V the origin must represent the location of a residence and not that of the firm. It should be noted, however, that either designation for the origin conforms with the concept that the net wage function depicts the relationship between travel time and the net wage.

Limited to a given vector.--The net wage function depicts the relationship between travel time and the net wage for those spatial locations lying along a given vector. Given the assumption of no contiguous local labor markets, a vector is defined as a linear curve passing through the spatial location of the firm or complex of firms. Figure 7 depicts the iso-time map from which Table 2 and Figure 6 are derived. The vector described by the graph of the net wage function in Figure 6 is V_1V_1. Spatial locations A, B, C, D and E are shown thereon. By rotating the V_1V_1 curve clockwise about the spatial location of the firm a second vector can be derived such as V_2V_2. A net wage curve

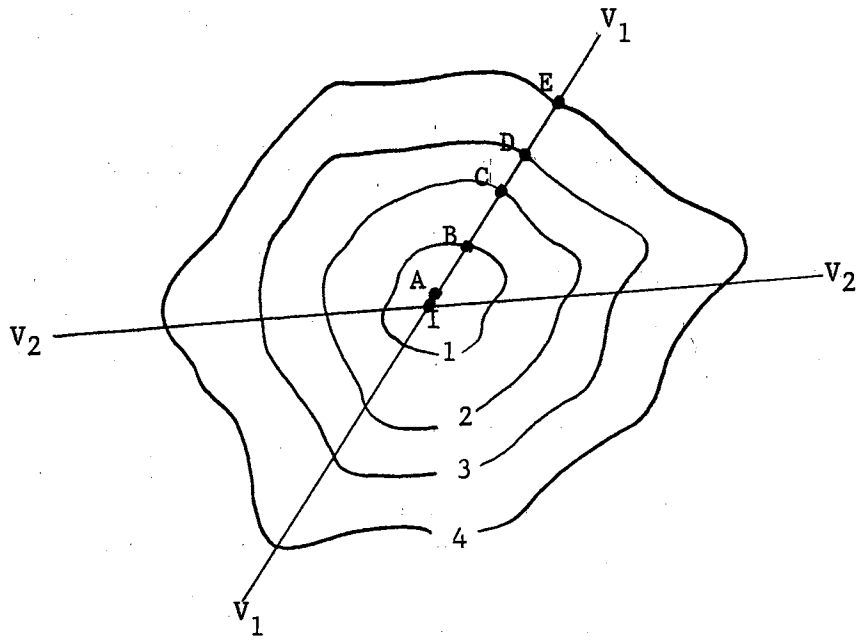

Figure 7

depicting the relationship between travel time and the net wage can in turn be constructed for spatial locations lying along this vector. In similar fashion other vectors and the respective net wage curve for each can be generated. Thus an infinitesimal number of vectors and the corresponding net wage curve for each provide complete coverage of all possible spatial locations.

The introduction of contiguous local labor markets alters the foregoing definition of a vector. Although contiguous local labor markets are not introduced until Chapter VI, their implications for the concept of a vector will be set forth now. Such a procedure minimizes the possibility of the reader fixing in mind a simplified definition that is not appropriate for later stages of analysis. Further, this procedure tends to fix more firmly in mind the definitional concept that a net wage curve is applicable only for those spatial locations lying

along a given vector.[12]

Given a contiguous local labor market, a vector is defined as a locus of points connecting both centers of employment and passing through only one spatial location that is of equal round trip travel time with respect to both centers; the other spatial locations through which the vector passes are such that for each the summation of round trip travel time to both centers is identical to that yielded for the spatial location which is of equal round trip travel time with respect to both centers. Thus a given vector is non-linear except in that case where a straight line passes through both centers of employment and a spatial location that is located halfway between them in terms of travel time.

The foregoing conclusions can be illustrated with the aid of Figure 8. The spatial location of the two employment centers is represented by the points labeled I and II. A system of iso-time curves for each center is also shown. From spatial location K the round trip travel time to either employment center is identical. This condition also is fulfilled by spatial locations L, M, N, O, P, Q, R and S. This must not be construed as meaning that travel time is the same for each such spatial location. To the contrary, the travel time is not the same for each point as shown in Figure 8: it is least for location O, greatest for locations K and S. Curve BL is the locus of points representing such spatial locations.

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[12]A rereading of the analysis to follow is suggested after completing Chapter VI. At such time the full implications of the material will be more readily apparent. However, the advantages gained from introducing the material at this stage of development outweigh the disadvantages.

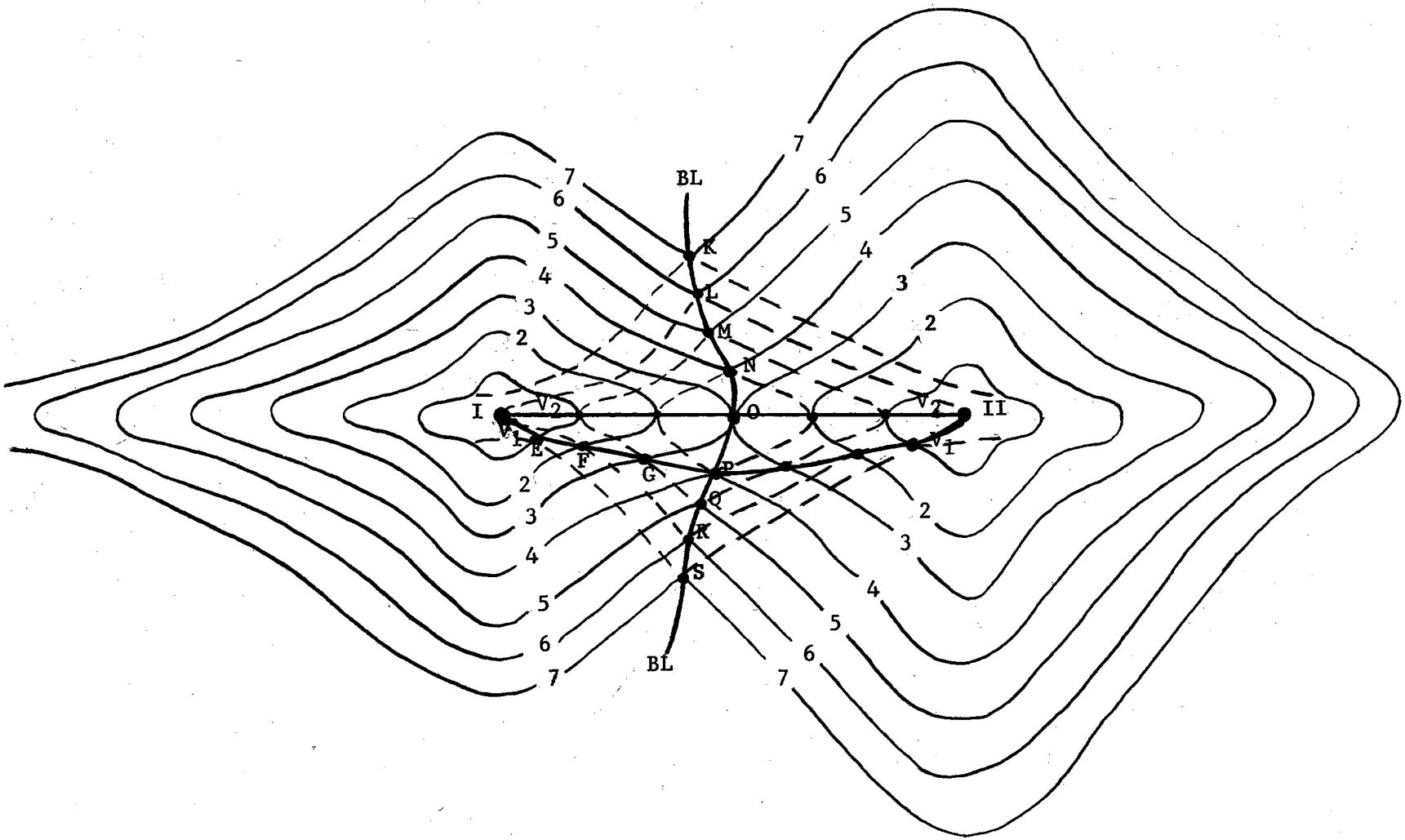

Figure 8

The curve connecting employment centers I and II and passing through spatial location P represents one vector. It is labeled V_1V_1. Note that it meets the conditions set forth in the above definition of a vector: (1) it connects both employment centers, (2) it passes through only one point on the BL curve, and (3) the other spatial locations through which the vector passes are such that for each the summation of round trip travel time to both centers is identical to that yielded for spatial location P. The summation of round trip travel time to both centers is eight units of travel time for spatial location P (4 units plus 4 units), spatial location G (3 units plus 5 units), spatial location F (2 units plus 6 units) and spatial location E (1 unit plus 7 units).

The net wage curve for vector V_1V_1 depicts the relationship between the net wage and travel time only for those spatial locations lying along that vector. The curve labeled V_2V_2 represents the only linear vector that can occur between the two centers of employment. To depict the relationship between the net wage and travel time for spatial locations lying along vector V_2V_2 requires a different net wage function diagram.[13]

Termination of a net wage function.--Given the wage paid by the firm, the population base and the tastes and preferences of individuals for their current place of residence, there will be some point in terms of travel time beyond which the local labor market for a firm will not

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[13]Spatial locations lying on the BL curve correspond to those indicated by the intersection of the net wage curve for each firm. For the appearance of such a graph see Figure 20 in Chapter VI. Assuming the given vector for Figure 20 is V_1V_1 shown in Figure 8, then the relationship between the net wage and travel time is for those spatial locations lying on the V_1V_1 curve of Figure 8.

extend.[14] Point G on the graph of the net wage function, corresponding to travel time TT_z and net wage W_z, in Figure 6 depicts such a location. The net wage for workers residing beyond travel time TT_z is insufficient to induce them to accept employment at firm I. To provide a logical foundation for this concept as well as for the entire theory of local labor market delimitation, it is appropriate at this point to undertake an analytical description of the individual as a supplier of labor in space. This is the task of the next two chapters.

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[14]The assumption that there are no contiguous local labor markets is still applicable.

CHAPTER IV

THE RESIDENTIAL PREFERENCE FUNCTION

Defined

The theory of local labor market delimitation recognizes that workers do have ties to their place of residence that tend to interfere with the more conventional theoretical concept of perfect labor mobility. The strength of these ties varies with the individual. For some it will be great. For others quite weak. The analytical tool developed to assist in depicting the strength of an individual worker's preference for his residential location is the "residential preference function." This function represents that net wage for each travel time that is just sufficient to bring into the market place the laborer's services. Any point lying below the graph of the function will not bring forth his services. Any point lying above the graph of the function will. It is a positive functional relationship. Given the strength of tastes and preferences for his current place of residence, the greater the net wage the greater the travel time the worker will be willing to spend in going to and from work, up to some point.

Derivation

Figures 9(a) and 9(b) will be used to illustrate the graphic derivation of a residential preference function. The vertical axis

represents dollars and is used to measure the wage paid by the firm as well as the individual's net wage. The horizontal axis represents travel time which is used to indicate alternative locations of the firm(s) with respect to the individual's place of residence. The origin represents the spatial location of the individual's residence.[1]

Theoretically, the plot of an individual's residential preference function can be derived by controlled experimentation. The first step in such an experiment is to determine one point lying on a graph of the function for a given travel time. Assume the spatial location of the worker's place of employment is represented by TT_5 units of travel time (round trip) in Figure 9(a), and that his net wage ($W_n = W - C_n$) is W_5. Point A depicts this combination of travel time TT_5 and net wage W_5. To determine whether or not point A is on the residential preference curve the wage paid by the firm will be decreased by an infinitesimal amount. Other things equal, this will reduce the net wage by an equal amount.[2] This combination of an infinitesimally lower net wage, W_4, and the same travel time, TT_5, is represented by point B. Following this adjustment

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[1]It is important to recognize the difference in the designation of the origin for Figures 9(a) and 9(b) and for Figures 5 and 6 which were used in the graphic derivation of the net wage function. See page 37. On the other hand the designation of the origin set forth above does not preclude the construction of a net wage curve as previously pointed out. See pages 42-43.

[2]This statement can be verified by a simple arithmetic example. Prior to a reduction in the wage paid by the firm the variables of the net wage equation ($W_n = W - C_n$) are: $W = \$12$ per day and $C_n = \$2$ per day. Therefore:

$$W_n = \$12 - \$2$$
$$W_n = \$10$$

If the daily wage paid by the firm is reduced by \$1, then the net wage will fall by \$1, ceteris paribus:

$$W_n = \$11 - \$2$$
$$W_n = \$9$$

the worker does not withdraw his labor services from the market. Thus point A is not a point on the residential preference curve. The experiment must be repeated. Once again the wage paid by the firm is decreased by an infinitesimal amount which in turn decreases the net wage by an equal amount, ceteris paribus. Point C represents the resulting combination: net wage W_3 and travel time TT_5. Following this reduction in his net wage the worker withdraws his labor services from the market.

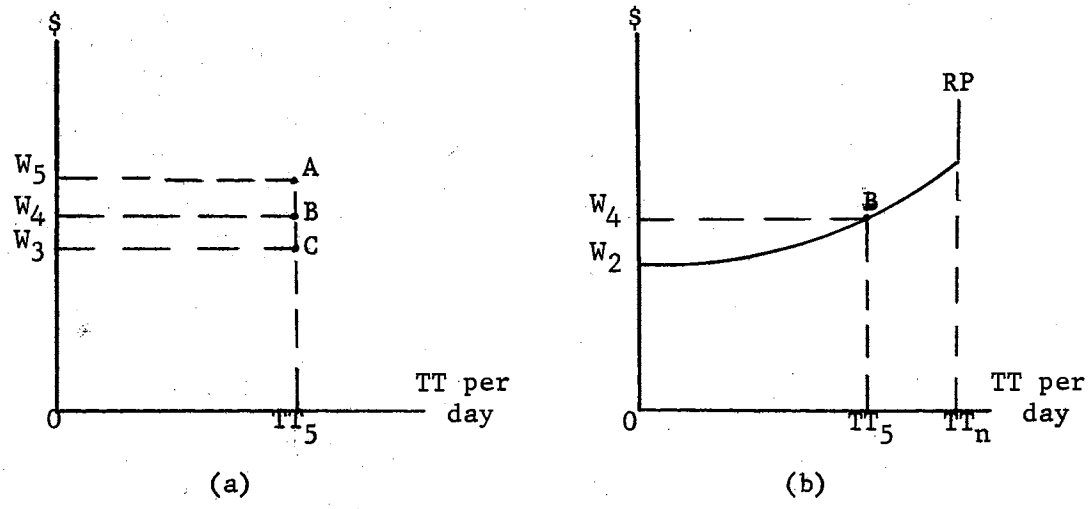

Figure 9

Net wage W_3 is insufficient to induce the worker in question to continue employment at the firm when the spatial location of his residence with respect to such place of employment is TT_5 units of round trip travel time.[3] Thus point B represents one point on the residential preference curve. Given travel time TT_5, net wage W_4 is just sufficient to induce the worker to sell his labor services. This meets the condition, previously stated, for a point lying on the residential preference curve.

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[3]The alternatives open to a worker when the net wage for a given travel time lies below his residential preference curve will be discussed in a later section.

Thus if the worker's place of residence is $TT_5/2$ units of travel time from the firm a net wage equal to or greater than W_4 will bring forth the individual's labor services. On the other hand any net wage below W_4 will be insufficient to induce the worker to sell his services to the firm in question.

The next step in the experiment is to derive a point on the individual's residential preference curve for a different travel time. By altering the place of employment with respect to the worker's residence, in terms of travel time, and repeating the process utilized to derive point B for travel time TT_5, a second point on the residential preference line can be derived. In similar fashion additional points lying on the locus can be derived. By repeating this process for an infinite number of travel times a locus of points representing the individual's residential preference function is generated.

The curve so derived will slope upward and to the right as illustrated in Figure 9(b). It is designated RP for purposes of graphic presentation. At any point on this curve, the net wage corresponding to the indicated travel time is just sufficient to induce the individual to sell his labor services. For example, to induce the individual to sell his labor to the firm located $TT_5/2$ units of travel time from his residence necessitates a minimum net wage of W_4. To induce the worker to spend more time than TT_5 units in traveling to and from work necessitates a larger net wage. The increase required in the net wage for a greater travel time is that amount necessary to compensate the worker for the substitution of travel time for leisure time, given his tastes and preferences for place of residence.

Conformity With Indifference Curve Analysis

The foregoing discussion concerning the shape of the residential preference function conforms with the principle of diminishing marginal rate of substitution derived from indifference curve analysis. In terms of the problem at hand this principle holds that with each successive substitution of income for leisure time, the individual is less willing to give up an additional unit of leisure time.

Figure 10 provides a graphic illustration. The x axis is marked off in equal units of leisure time between A and K. At point A the individual has very little leisure time. Thus leisure time is very important to him. To gain an additional unit of leisure time, and still

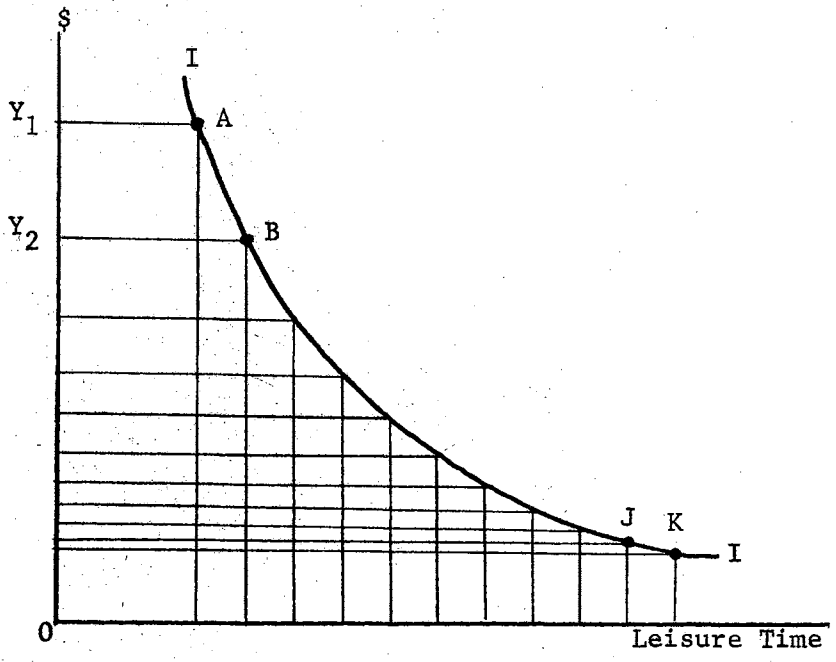

Figure 10

remain on indifference curve II, the individual would give up $Y_1 - Y_2$ income. Such a substitution of leisure time for income places the individual at point B. However with each unit increase in leisure time the

individual will give up less and less income. The marginal rate of substitution of leisure time for income is diminishing. At point J the individual would give up a very small amount of income for an additional unit of travel time, as the diagram indicates. The proposition that the residential preference curve slopes upward and to the right, as illustrated in Figure 9(b), rests upon the foregoing economic principle.

Point of Perfect Inelasticity and The Y Intercept

The shape of the residential preference function, as depicted in Figure 9(b), indicates that the maximum distance a person will travel to work in terms of travel time varies directly with the net wage up to some point. Beyond some point, however, travel time becomes completely insensitive to the net wage. Such a point is represented by travel time TT_n in Figure 9(b). At this point travel time becomes completely net wage inelastic. An ultimate limitation is placed upon travel time by the twenty-four hour day. A person working eight hours a day cannot spend more than sixteen hours traveling to and from work. Of course the point of perfect inelasticity will occur much sooner due to sleeping, eating, and recreational requirements.

The residential preference curve will intersect the y axis at some positive point above the origin. This point of intersection represents that wage offered by the firm that will just induce the individual to supply his labor when he has no travel costs. Such a situation occurs when the worker resides next to his place of employment which means that $C_n = 0$ and therefore $W = W_n$. Net wage W_2 in Figure 9(b) is such a wage. It is that wage just sufficient to induce the individual in question to sell his services. It should be kept in mind that for other individuals

such a wage may be either insufficient or more than sufficient to bring forth their labor.

For Different Individuals

As previously indicated the strength of tastes and preferences for a given residential location will vary among individuals. The effects of these variations upon the residential preference function and their implications for labor supply are depicted in Figure 11. The form of the functions for three hypothetical individuals, A, B and C, labeled RP_a, RP_b and RP_c respectively, are shown. Individual A has stronger preferences for the spatial location than does individual B. In turn individual B has stronger preferences for the spatial location than individual C. Now if the net wage were W_4 and the travel time to the

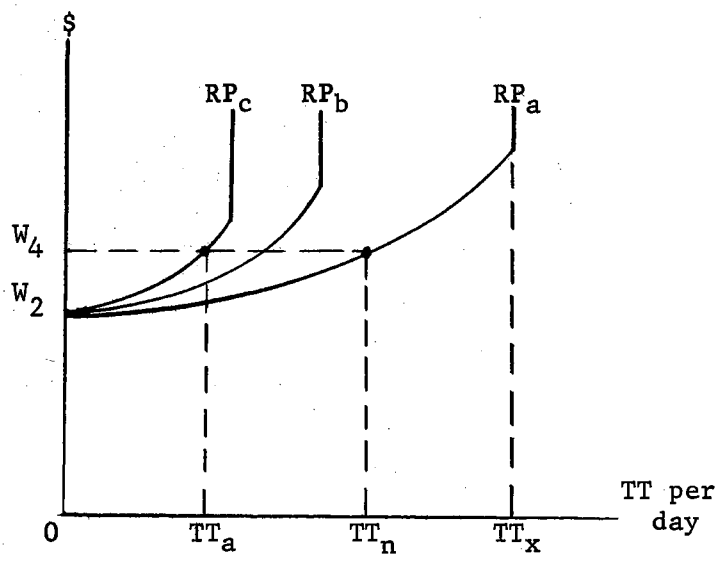

Figure 11

firm were TT_a, then all three individuals would sell their labor services to the firm. However, if the travel time were TT_n, then only individual A would accept employment at the firm. If the travel time to the firm exceeds TT_x none of the three individuals will accept

employment at the firm, regardless of the net wage. At the other extreme, when travel time is zero and the net wage is W_2 or greater all three individuals will accept employment at the firm. As indicated by the foregoing discussion, the residential preference function adds theoretical precision to the derivation and explanation of the labor supply curve.

It must be emphasized that the plot of the residential preference function of different individuals need not intersect the y axis at the same point, as occurs in Figure 11. Assuming $C_n = 0$, some individuals will withhold their labor from the market at wage W_2; whereas other individuals would be willing to sell their labor at a wage below W_2. This phenomenon conforms with the economic principle that the labor supply curve slopes upward and to the right. In Figure 12 three hypothetical residential preference curves, for the individuals A, D, and E,

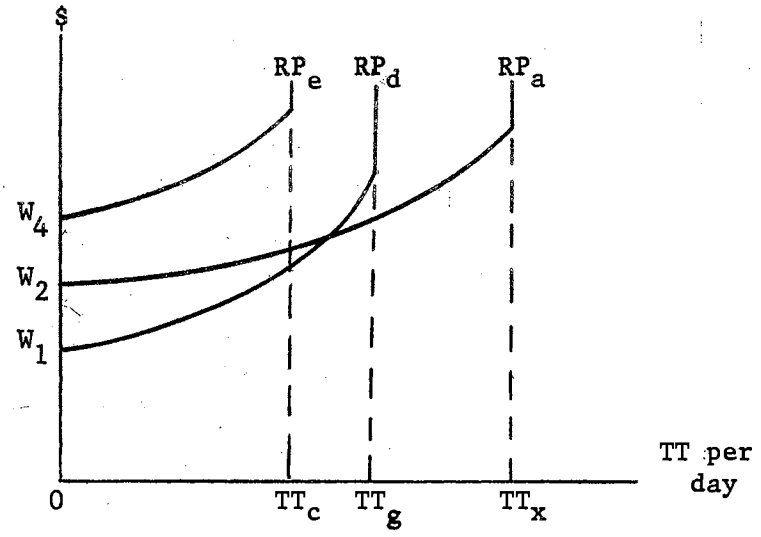

Figure 12

labeled RP_a, RP_d and RP_e respectively, are shown. The y intercept of each curve is different. Thus, the net wages necessary to induce

individual A, D, and E to sell their labor to the firm, when travel time is zero, are W_2, W_1, and W_4 respectively. Also the travel times beyond which individuals A, D, and E will withhold their labor from the firm regardless of the net wage, are TT_x, TT_g and TT_c respectively.

It should be kept in mind that the residential preference functions discussed above are for individuals residing at spatial locations that are of equal travel time with respect to the firm for all the various alternative locations of the firm. For spatial locations with different travel times the process would have to be repeated for each specified travel time--that is different diagrams would have to be constructed. For purposes of simplifying the study it is assumed that a residential preference function relates to a single geographic location. This assumption does not preclude the existence of two or more functions for a given spatial location.[4]

[4]Several persons of a given household may be members of the labor force. Duplexes and apartment houses also account for the existence of two or more functions for a given spatial location.

CHAPTER V

THE NET WAGE FUNCTION AND THE RESIDENTIAL PREFERENCE FUNCTION

A Determinant of the Supply of Labor

A seller or non-seller.--By plotting the net wage function on the residential preference function diagram it can be determined whether or not the individual, given travel time to and from the firm, will sell his labor to the firm.[1] The point of intersection of the net wage curve and the residential preference curve indicates the maximum amount of time the individual will allocate for travel to and from work, given the wage paid by the firm (where W = VMP of labor). This can be illustrated diagramatically. In Figure 13 the value of marginal product of labor and thus the wage paid by the firm is assumed to be VMP_{L_1}. In turn NW_1 is assumed to be the graph of the net wage function given this wage. Individual A's hypothetical residential preference curve is designated RP_a. The net wage and travel time corresponding to the point of intersection of these two curves are W_4 and TT_g. The net wage function indicates that for TT_g units of travel time the net wage ($W - C_n$) will be W_4.

[1] In those diagrams depicting the net wage function in Chapter III, the spatial location of the firm was a constant. However by placing the net wage function on a residential preference function diagram the spatial location of the firm is variable while that of the residence is fixed. It is essential that this procedure be kept firmly in mind throughout the analysis of this chapter.

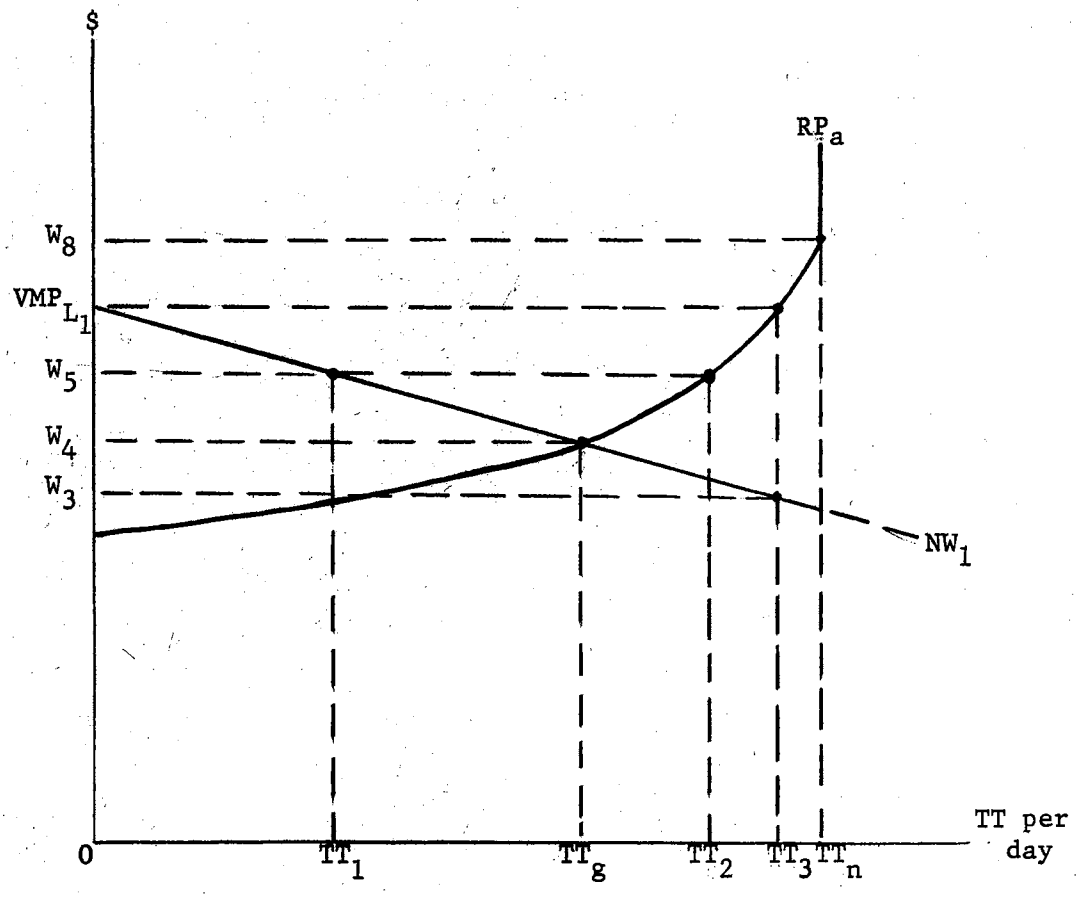

Figure 13

In turn the residential preference function for individual A indicates that net wage W_4 is just sufficient to induce him to sell his labor to the firm located $TT_g/2$ units of travel time from the residence. Thus based upon a wage of VMP_{L_1} the maximum time individual A will spend in traveling to and from work is TT_g.

Given the foregoing data, the individual will sell his labor to the firm so long as his residence with respect to the firm is $TT_g/2$ units of travel time or less. Travel time TT_1 in Figure 13 depicts such a situation. For this travel time the individual's net wage would be W_5. Such a net wage is more than sufficient to induce A to sell his labor to the firm. For this net wage, A would be willing to spend TT_2 units of time

traveling to and from work. On the other hand if A's residence with respect to the firm is at a travel time greater than that indicated by the intersection of the net wage curve and residential preference curve ($TT_g/2$), he will not sell his labor to the firm. TT_3 is such a travel time. For travel time TT_3 the net wage function indicates a wage of W_3. However, the residential preference function indicates that the minimum net wage which will induce A to travel TT_3 units is VMP_{L_1}. Since $W_3 < VMP_{L_1}$ individual A will not sell his labor to the firm.

Alternatives for a non-seller.--The alternatives open to the individual whose travel time to and from the firm exceeds that indicated by the intersection of the two curves warrants brief attention. In such instances the individual faces two general alternatives with respect to his place of residence: (1) despite voluntary unemployment the individual may elect to remain at his current place of residence, or (2) as a result of voluntary unemployment the individual may elect to change his place of residence. If the individual is a secondary breadwinner there is a strong probability that the first alternative will be selected. On the other hand, if the individual is the primary breadwinner the probabilities are that the second alternative will be selected.[2] If, however, the primary breadwinner expects the wage paid by the firm to rise in the near future, which would shift the net wage curve upward by the amount of the increase in the wage, ceteris paribus, he may remain at his current place of residence. In such an instance, the individual would consider

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[2]In this study the primary breadwinner is defined as the individual upon whom the family unit is basically dependent for its income. As a rule of thumb, this individual can be identified as the one providing more than one-half of the family's income. These definitional concepts are utilized to expedite the analysis. They are not intended as precise definitions, as the foregoing wording indicates.

voluntary unemployment as only temporary. He would prefer to dissave for the duration of the voluntary unemployment rather than alter place of residence.[3]

These conclusions concerning the alternatives open to the individual and the probability of each, depending upon whether the individual concerned is a primary or secondary breadwinner, rest upon an appeal to experience. A family must have a source of income. Thus if the spatial location of the residence precludes employment for the primary breadwinner, then eventually the family must move. On the other hand, a secondary breadwinner's contribution to family income may not be considered essential. In such instances the preclusion of employment, due to travel time, for a secondary breadwinner need not necessitate a change of residence. Further it appears logical to conclude that generally the residential preference curve for the primary breadwinner would lie to the right of the one for the secondary breadwinner. For example in Figure 12 the residential preference curve for the primary breadwinner might be the one labeled RP_a, whereas for the secondary breadwinner the curve labeled RP_e might be appropriate.

The Maximum Extent of a Local Labor Market

Previously it was stated that given the wage paid by the firm, the population base and the tastes and preferences of individuals for their current place of residence, there will be some point in terms of travel

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[3]It should be recognized that an increase in the strength of the individual's tastes and preferences for his place of residence could shift the residential preference curve to the right sufficiently so that travel time no longer precludes employment at the firm. Since tastes and preferences for place of residence are taken as given in the theory of local labor market delimitation this possible occurrence is ruled out.

time beyond which the local labor market of the firm cannot possibly extend, even if there are no contiguous local labor markets. Point G on the plotted net wage function in Figure 6 was designated such a point. Thus for the vector concerned in Figure 6, the local labor market for firm I will not extend beyond travel time TT_z, given the wage rate W_{10}. With the aid of the residential preference function it is now possible to explain the determination of such a point.

The value of marginal product of labor a constant.--Theoretically a point lying on the curve depicting the maximum extent of a local labor market in terms of travel time, assuming no contiguous local labor markets and given the wage paid by the firm, is derived as follows. Given the form of the net wage function the first step is to determine where it would intersect the x axis. The analysis is initiated at that travel time indicated by this intersection or a travel time of sixteen hours, whichever is smaller.[4] Having determined the appropriate travel time at which to initiate the analysis, the next step involves successive and infinitesimal movements upward and to the left along the net wage line. Following each infinitesimal move, the residential preference function for each individual at the indicated spatial location is examined. So long as the intersections of the net wage curve and all the residential preference curves yield travel times smaller than that required to travel to and from the firm, the location is beyond the maximum boundary of the local labor market, given the value of marginal product of labor (and

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[4]Assuming the working day to be eight hours, then the maximum amount of time that could be devoted to travel is sixteen hours. Thus only in those instances where the intersection of the net wage function with the x axis yields a travel time of less than sixteen hours will it be used to establish the initiating point of the analysis.

thus the wage paid by the firm). By such successive infinitesimal movements up the net wage curve a spatial location is eventually encountered where the travel time indicated by the intersection of the two curves is identical to or smaller than that required of the individual in traveling to and from the firm. Such a spatial location represents the maximum extent of the local labor market for the vector under study. Point G in Figure 6 depicts a point so derived. In terms of Figure 6 no labor will be forthcoming beyond travel time TT_Z along the indicated vector at a net wage below W_Z. Thus the intersection of the net wage curve and the residential preference curve for that employee furthest removed from the firm, in terms of travel time, determines that spatial point beyond which the local labor market will not extend on a given vector, given the value of marginal product of labor. By repeating the foregoing process for an infinite number of vectors a curve depicting the maximum possible extent of the local labor market is generated for a given value of marginal product of labor.

The value of marginal product of labor a variable.--Throughout the foregoing discussion it was continuously emphasized that the analysis held only for a given value of marginal product of labor. The curve depicting the maximum possible extent of the local labor market, as well as any point on that curve, such as G in Figure 6, is variable with the wage paid by the firm (where W = VMP of labor) up to some point. The point beyond which the local labor market cannot extend, regardless of the wage, is established by that residential preference curve whose point of perfect inelasticity yields the largest travel time with

respect to the firm.[5] Assume that Figure 13 portrays the individual whose residential preference function, at the point of perfect inelasticity, yields the greatest travel time with respect to the firm (TT_n) for the vector under study. Given the value of marginal product of labor VMP_{L_1}, this individual will not sell his services to the firm. Thus the point depicting the maximum extent of the local labor market for this vector will be of a lesser travel time. However, if the value of marginal product of labor rises sufficiently to yield the individual a net wage of W_8, the maximum extent of the local labor market for this vector, in terms of travel time, is TT_n. The spatial extent of the market for the vector in question cannot possibly extend beyond the spatial location of this individual's residence regardless of the wage paid by the firm, ceteris paribus. For the vector concerned TT_n is the maximum travel time that can possibly prevail. Thus the ultimate limit placed upon the spatial extent of the local labor market for a given vector, in terms of travel time, is determined by the intersection of the net wage curve with the perfectly inelastic portion of that

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[5]It should be recognized that the point of perfect inelasticity of other residential preference functions may yield a greater travel time. Some individuals may have even stronger tastes and preferences for their place of residence than does the individual whose residential preference function establishes one point on the curve depicting the maximum spatial extent of the local labor market regardless of the wage. Such individuals would be willing to spend a greater time traveling to and from the firm than that indicated by the travel time designating the maximum extent of the market. However, due to the location of their residence with respect to the firm, the travel time for such individuals is only a portion of the amount each would be willing to devote to travel. The actual travel time that such individuals must allocate for traveling to and from work is of course less than that travel time indicated by the point of perfect inelasticity of the residential preference function used to depict the maximum extent of the local labor market regardless of the wage paid by the firm.

residential preference curve yielding the greatest travel time with respect to the firm. Once this point is reached additional increases in the wage paid by the firm will not increase the quantity of labor available to the firm by extending the geographic scope of the local labor market.[6] Such a point places the maximum limit upon the spatial extent of a local labor market for the vector concerned.

A Money Measure of Tastes and Preferences For Place of Residence

The residential preference function and the net wage function also provide a means of measuring in money terms the strength of an individual's tastes and preferences for his place of residence. This ability to assign a monetary measure to the individual's tastes and preferences for his place of residence, though not absolutely essential for the theory of local labor market delimitation, adds a high degree of precision and depth to the theory. It also affords further evidence of the flexibility and usefulness of such new analytical tools as the net wage function and the residential preference function. The process by which this is accomplished will be demonstrated with the aid of Figures 14 and 15. The residential preference function depicted in both diagrams is for the same individual. The graph of the net wage function is identical in both diagrams.

Travel time equals that yielded by the intersection of the net wage curve and the residential preference curve.--In Figure 14 the firm is

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[6]Such wage increases may, however, result in possible increases in the quantity of labor available to the firm by inducing individuals within the confines of the local labor market to sell their labor to the firm--labor which was withheld at lower wage rates. This question receives additional treatment in Chapter VIII which is concerned with the disturbance of local labor market equilibrium and its re-establishment.

assumed to be $TT_5/2$ units of travel time from the individual's place of residence (represented by the origin). Given this travel time, the corresponding net wage is just sufficient to induce the individual to supply his labor to the firm. Now by moving closer to the firm the individual could increase his net wage and thus his net daily income. To the extent that he does not do so indicates in part the sacrifice he is willing to make in money terms to remain at his current place of residence. For example by moving to a residence adjacent to the firm the individual could increase his daily net income by amount OB - OA. However this dollar figure provides only a partial measure of the strength of his tastes and preferences for place of residence. If the individual

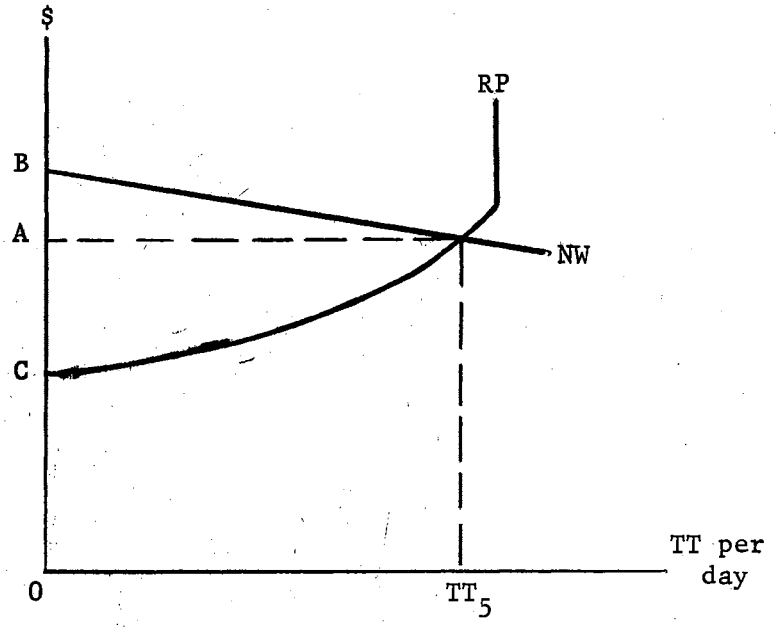

Figure 14

moves closer to the firm, the amount of time spent in traveling to and from work is reduced. He is able to substitute leisure time for travel time. Further, the closer the firm to the individual's place of residence, in terms of travel time, the smaller the net wage necessary to induce the

individual to supply his labor to the firm. Thus OA - OC represents that part of the wage necessary to induce the individual to travel TT_5 units of travel time. Given the value of marginal product of labor, then to derive the complete sacrifice, measured in money terms, made by the worker in remaining at his place of residence necessitates that OA - OC be added to OB - OA.

So long as the wage paid by the firm remains unchanged the money value OB - OC represents the strength of the individual's tastes and preferences for his place of residence. By moving to a location adjacent to the firm, the individual can increase his net income by OB - OA as well as his leisure time by TT_5 units which has a money measure equivalent to OA - OC. Since the individual does not select this alternative, it is concluded that the utility derived from the higher net wage and the greater leisure time is not sufficient to offset the loss in utility that would be incurred by changing place of residence. In the foregoing way one derives in money terms a measure of the worker's tastes and preferences for his place of residence.[7]

Travel time is less than that yielded by the intersection of the net wage curve and the residential preference curve.--Figure 15 illustrates the derivation of a money measure for the sacrifice made by the individual in remaining at his current place of residence when the travel

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[7]In all probability variations in individual tastes and preferences for housing combined with spatial limitations will preclude the possibility of all workers residing adjacent to the firm. The implications, stemming from this recognition, for the analysis under discussion will be introduced shortly. On the other hand it should be recognized that given certain conditions, all workers could conceivably reside adjacent to the firm. For example, a sufficient number of apartment buildings surrounding the firm could house its entire work force. The larger the work force the higher the buildings comprising the apartment complex.

time to and from the firm is less than that indicated by the intersection of the net wage curve and the residential preference curve. The firm is assumed to be $TT_2/2$ units of travel time from the individual's residence. For this travel time the net wage is OD - OE greater than necessary to induce the individual to sell his labor to the firm. Still, however, the individual could increase his net wage by amount OB - OD by moving to a spatial location adjacent to the firm. Further such a move would

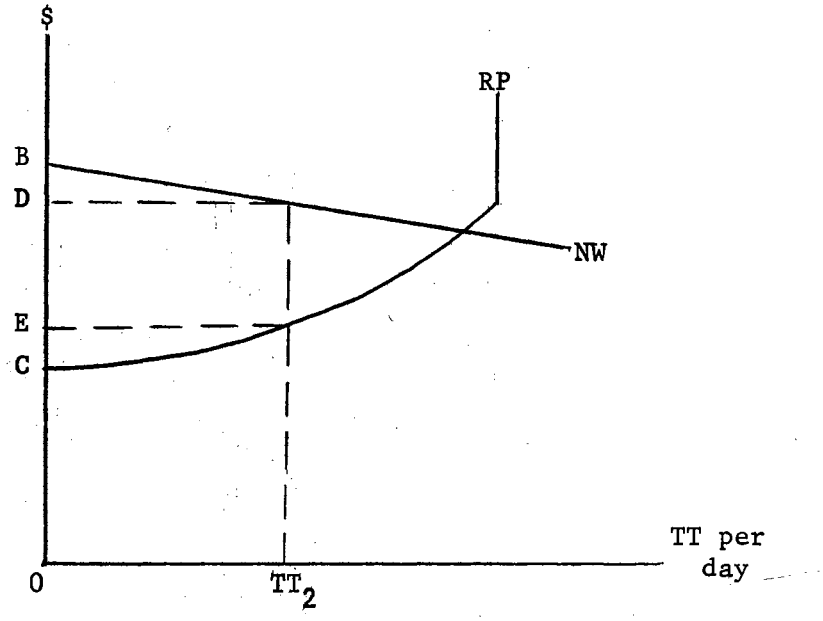

Figure 15

decrease travel time by TT_2 units, which has a dollar value of OE - OC. Thus (OB - OD) + (OE - OC) indicates in money terms the sacrifice incurred by the individual in remaining at current place of residence when travel time to and from the firm is TT_2 units. The dollar value OD - OE represents the additional sacrifice the individual would be willing to incur and still supply his labor to the firm, given the prevailing value of marginal product of labor.

Complete utilization of space precludes movement to a residence

nearer the firm.--In the foregoing derivation of a money measure of the sacrifice made by the individual in remaining at his current place of residence, it was assumed that he was free to move to a location adjacent to the firm. In reality, however, this alternative may not always be open to the individual. A given spatial area is limited in the number of individual housing units it can accommodate. Thus the spatial area adjacent to the firm may be so completely utilized that further immigration is precluded. In such instances, assuming homogeneity of housing, the price mechanism will tend to establish a price (for purposes of simplicity it is helpful to think in terms of rent) for each group of residences having equal travel time with respect to the firm, within the completely utilized area, so that demand and supply are equated. In terms of dollar sacrifices involved, individuals residing at the periphery of the completely utilized area, once the foregoing system of equilibrium prices prevail, fall into one of two categories: (1) those who would be indifferent to locations within the completely utilized area, and (2) those who would find that their dollar sacrifices would actually increase by moving to a location within the completely utilized area. For those individuals designated as indifferent, the difference in rent (price) would be exactly equal to the expenses incurred in traveling to work plus the dollar value attached to the required substitution of travel time for leisure time associated with residential locations on the periphery. For those individuals who would maximize their position by remaining on the periphery, the difference in rent exceeds the cost of traveling to work plus the dollar value attached to the leisure time that must be foregone due to such travel.

The foregoing remarks conform with the principles of supply and

demand analysis. The price (rent) of residences within the completely utilized area is determined by the intersection of the demand curve for such property with the perfectly inelastic supply curve of such property. The individual(s) who is indifferent accounts for the equilibrium differential in rent. Those individuals minimizing their dollar sacrifices by remaining on the periphery account for that portion of the demand curve located to the right of its intersection with the supply curve. In turn those individuals residing within the completely utilized area account for that portion of the demand curve to the left of its intersection with the supply curve. The foregoing statements can be substantiated analytically with a simplified model. Figures 16, 17, 18 and 19 will assist in the analysis.

The model is based upon the following assumptions. There is only one firm. The labor force consists of four individuals, designated for purposes of identification as A, B, C and D. The housing supply consists of four separate dwelling units. The four residences are identical in all respects except for their spatial locations. Two of the residences are located adjacent to the firm, whereas the remaining two are located $TT_1/2$ units of travel time from the firm. The equilibrium rent for the latter two residences is known. Since the residences in either location satisfy each individual's tastes and preferences for housing equally well, the individual's residential preference function is appropriate for either spatial location. Thus the origin of Figure 16 represents both residential spatial locations. For one residential location travel time TT_1 depicts the location of the firm. For the other residential location the location of the firm is depicted by zero travel time. Given these conditions the price mechanism will allocate the four available residences among the

four individuals. The resulting allocation will be one that maximizes the utility of each individual; or in slightly different terms minimizes the sacrifices incurred by the individual.

Since the equilibrium rent for the two residences located $TT_1/2$ units of travel time from the firm is assumed to be known, the task at hand is to determine what constitutes the equilibrium differential in rent between the two spatial locations. That is, by how much, if any, will the rent for those residences adjacent to the firm exceed the equilibrium rent for those residences located $TT_1/2$ units of travel time from the firm. The derivation of this differential in turn enables one to derive by simple addition the equilibrium rent for the residences adjacent to the firm. The equilibrium differential plus the equilibrium rent for those residences located $TT_1/2$ units of travel time from the firm yields the desired figure. Through the analysis to follow the equilibrium rent for those residences whose spatial location is $TT_1/2$ units of travel time from the firm will be represented by the constant amount X_1.

In Figure 16 the net wage function, NW_1, and the residential preference function for individual A, B, C and D, labeled RP_a, RP_b, RP_c and RP_d respectively, are depicted graphically. From this diagram a schedule of the rent differential each individual would be willing to pay for a residence adjacent to the firm can be derived. Columns 1 and 3 of Table 3 will represent such a schedule. Column 2 will represent the equilibrium rent for the two residences located $TT_1/2$ units of travel time from the firm. Column 4, the summation of columns 2 and 3, will indicate the maximum rent each individual would be willing to pay for a residence adjacent to the firm. Table 4, which will be derived

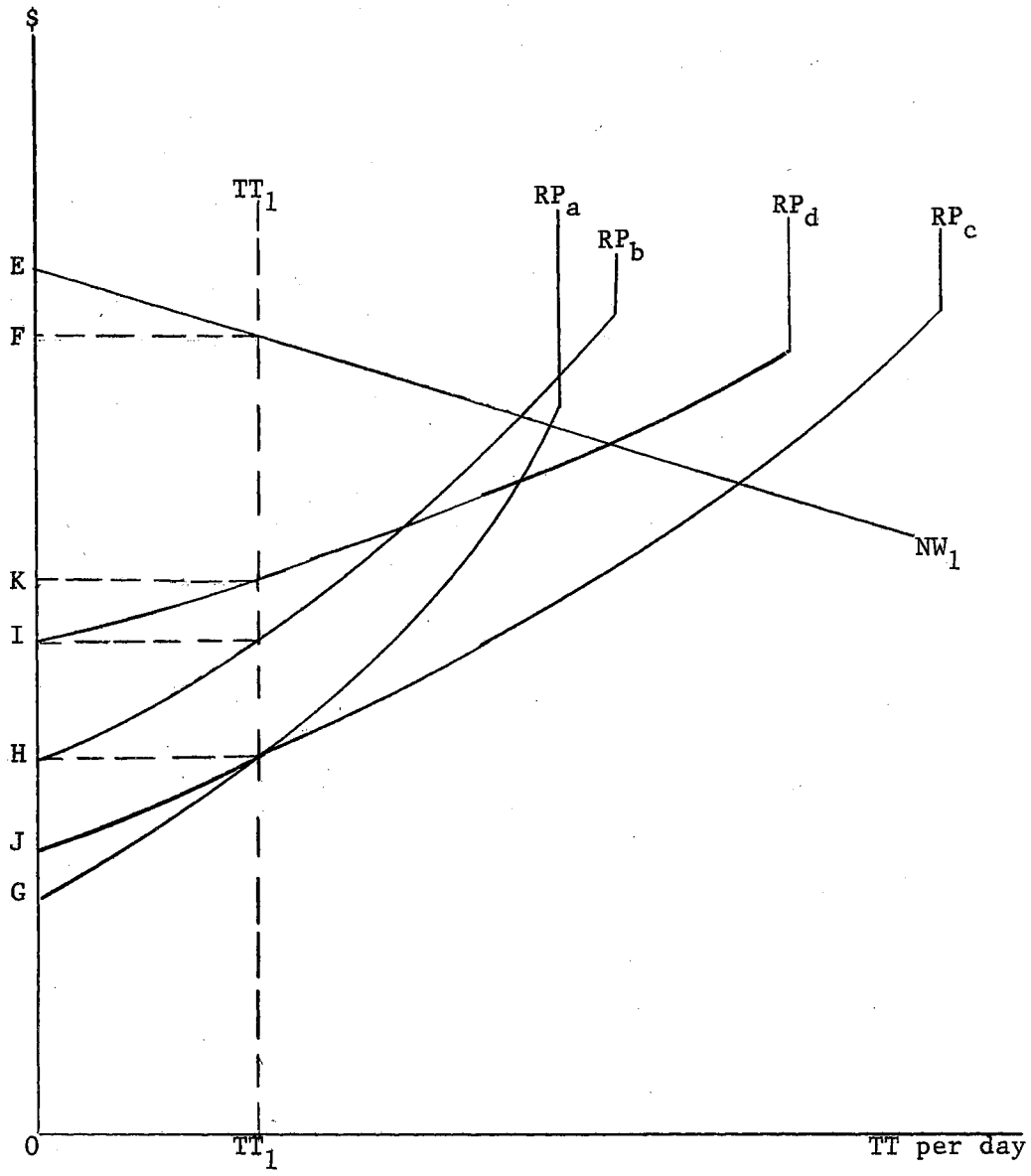

Figure 16

from Table 3, will represent the demand schedule for those residences adjacent to the firm. In Figure 17 the demand curve, based upon the data appearing in Table 3, will be plotted. The intersection of this demand curve with the perfectly inelastic supply curve will yield the equilibrium rent (price) for those residences adjacent to the firm.

Based upon Figure 16 the data for Tables 3 and 4 will now be

derived. By residing at a spatial location that is $TT_1/2$ units of travel time from the firm, individual A, given his residential preference curve RP_a and the net wage curve of NW_1, would incur travel expenses of OE - OF and a reduction in leisure time valued at OH - OG dollars. On the other hand by residing at a spatial location adjacent to the firm, the dollar sacrifices incurred by individual A can be reduced by the foregoing amounts. Thus A would be willing to pay an increased rent differential of (OE - OF) + (OH - OG) dollars for a residence adjacent to the firm. This differential added to the given equilibrium rent paid for residences located $TT_1/2$ units of travel time from the firm (represented by X_1 in column 2 of Table 3) yields the rent individual A would be willing to pay for a residence adjacent to the firm. In column 4 of Table 3 this rent is represented by P_{10}. For individual B the travel

TABLE 3

A HYPOTHETICAL DERIVATION OF THE RENT VARIOUS INDIVIDUALS ARE WILLING TO PAY FOR A FIXED SUPPLY OF RESIDENCES ADJACENT TO THE FIRM

(1)	(2)	(3)				(4)
Individual	Equilibrium Rent for Residences having a Travel Time of TT_1	Differential in Rent For Residences Adjacent To the Firm Based on $ Measure of Savings in Travel Cost & Travel Time				Rent Individual Willing to Pay For Residence Adjacent to Firm
A	$\$X_1$	+ (OE - OF)	+	(OH - OG)	=	P_{10}
B	X_1	+ (OE - OF)	+	(OI - OH)	=	P_8
C	X_1	+ (OE - OF)	+	(OH - OJ)	=	P_7
D	X_1	+ (OE - OF)	+	(OK - OI)	=	P_5

costs and money value attached to the foregone leisure time are OE - OF

and OI - OH respectively. Adding these two dollar amounts to X_1, then B would be willing to pay a rent of P_8 for a residence adjacent to the firm. In similar fashion the rent that individuals C and D will pay for a residence adjacent to the firm is derived. The rents so derived are listed in Table 3.

Columns 1 and 4 of Table 3 provide the necessary information for the construction of the demand schedule appearing in Table 4: This data is

TABLE 4

A HYPOTHETICAL DEMAND SCHEDULE FOR HOUSING
IN A COMPLETELY UTILIZED AREA

Quantity Demanded	Price (Rent)
1	P_{10}
2	P_8
3	P_7
4	P_5

in turn employed to generate the demand curve shown in Figure 17. The

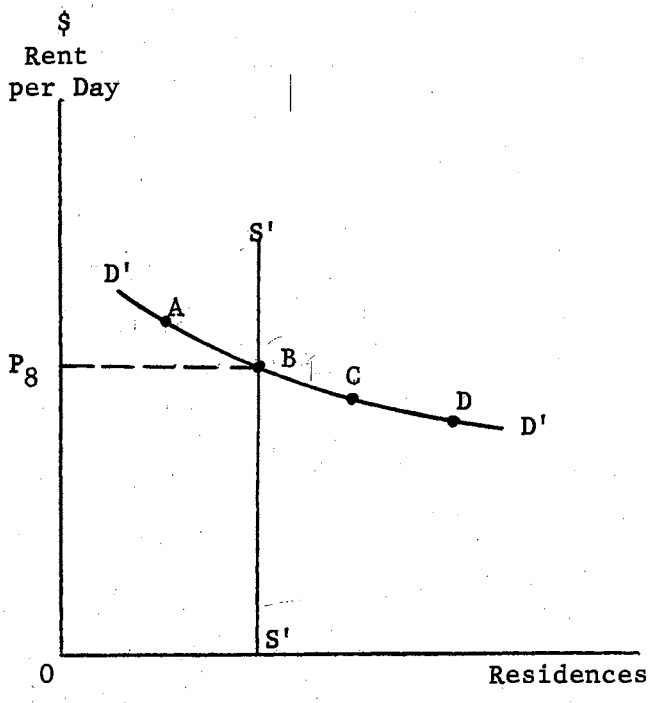

Figure 17

inelastic supply curve of Figure 17 conforms with the initial assumption that there are only two residences adjacent to the firm. The demand and supply curves in Figure 17 show that individuals A and B will reside in the two residences adjacent to the firm and that individuals C and D will maximize their position by residing at the two residences located $TT_1/2$ units of travel time from the firm. The equilibrium price for the residences adjacent to the firm is P_8.[8] The equilibrium differential in rent is thus equal to amount (OE - OF) + (OI - OH) of Figure 16. Given this equilibrium differential in rent, individuals C and D will actually minimize their dollar sacrifices by residing at those residences located $TT_1/2$ units of travel time from the firm.

The exclusion of immigration for a given area about the firm has significant implications for the net wage function and for the residential preference function. Given the equilibrium system of rents, the net wage curve becomes perfectly elastic throughout the travel time depicting the spatial area in which complete utilization precludes additional immigration. Such an area is depicted by travel time TT_1 in Figures 18 and 19. The

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[8]For this price to hold it is necessary to assume that P_8 exceeds P_7 by an infinitesimal amount. Figure 16 is constructed so as to depict this condition as far as possible and yet enable the reader to detect a difference with the naked eye. The distance OH - OJ is slightly smaller than the distance OI - OH.

If the difference in rent P_8 and P_7 is more than infinitesimal then in the long run the equilibrium price will tend to fall to P_7 leaving individual C indifferent between the two spatial locations. Since the supply of housing is fixed, by definition, and since individual B now resides at a residence adjacent to the firm, he can pay a rent of P_7 (the maximum amount individual C will pay) and still retain the residence. Other things equal, there will be no incentive for the supplier to change tenants nor for individual C to undertake the move. Thus once again it is shown that the equilibrium rent for the residences adjacent to the firm and fixed in supply is determined by the individual who is indifferent between the two locations.

residential preference curve of each individual residing outside of the area of complete utilization will become either perfectly elastic or negatively inclined throughout the travel time depicting the area in which immigration is precluded.[9] In computing the dollar sacrifices incurred by the individual, the existence of a completely utilized area has the same effect upon such computations as a shift rightward in the y axis to the travel time where complete utilization ceases. Thus when some portion of the local labor market about the firm is so completely utilized that further immigration is precluded, the sacrifices, measured in dollars, incurred by individuals residing at spatial locations beyond the periphery of such an area are less than in those instances where the individual is free to move to a location immediately adjacent to the firm if he so desires. Figures 18 and 19 provide an analytical depiction of the foregoing remarks.

Figure 18 portrays an individual who would be indifferent between a residential location $TT_1/2$ units of travel time from the firm and one adjacent to the firm. (This is the case where both curves become perfectly elastic throughout the travel time depicting the spatial area of complete utilization.) The travel time up to TT_1 depicts the area in which complete utilization precludes further immigration. For the residence located $TT_1/2$ units of travel time from the firm, the cost of travel is OD - OC and the dollar value of the leisure time foregone is

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[9]For those individuals residing within the completely utilized area, the residential preference curve will be either perfectly elastic or positively inclined throughout the travel time depicting the area of complete utilization. The curve will be positively inclined if the equilibrium differential in rent is less than the dollar sacrifices incurred by the individual if his residence were at the periphery of the completely utilized area.

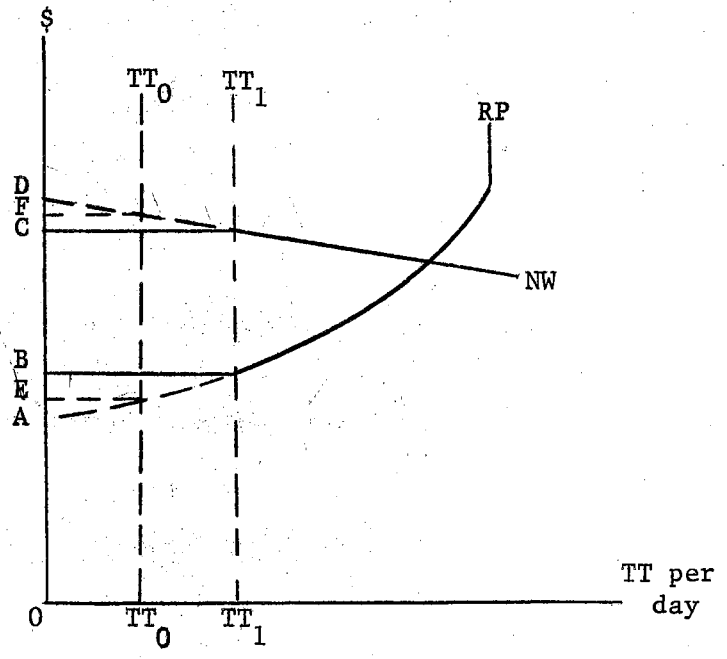

Figure 18

OB - OA. Since (OD - OC) + (OB - OA) is exactly equal to the additional rent the individual would pay for a residence adjacent to the firm, he is indifferent between the two locations in terms of dollar sacrifices involved. For a residence located TT_0 units of travel time from the firm, the equilibrium differential in rent is (OD - OF) + (OB - OE). Thus by incorporating the differentials in rent into the graph of the two functions, each becomes perfectly elastic up to travel time TT_1. As one moves from TT_1 toward the origin the increased rent just offsets the reduction in travel costs plus the dollar value of the leisure time gained.

Figure 19 depicts an individual whose travel cost plus the dollar value attributed to the required substitution of travel time for leisure time is less than the equilibrium differential in rent. The negative slope of the residential preference curve between 0 and TT_1 units of travel time indicates that as the individual moves closer to the firm

the increase in rent is greater than the dollar value the individual places upon the leisure time gained as a result of the decreased travel time. Amount OB - OA represents the excess of the rent differential over the dollar value attached to the leisure time gained as a result of the reduced travel time associated with a residence adjacent to the firm.

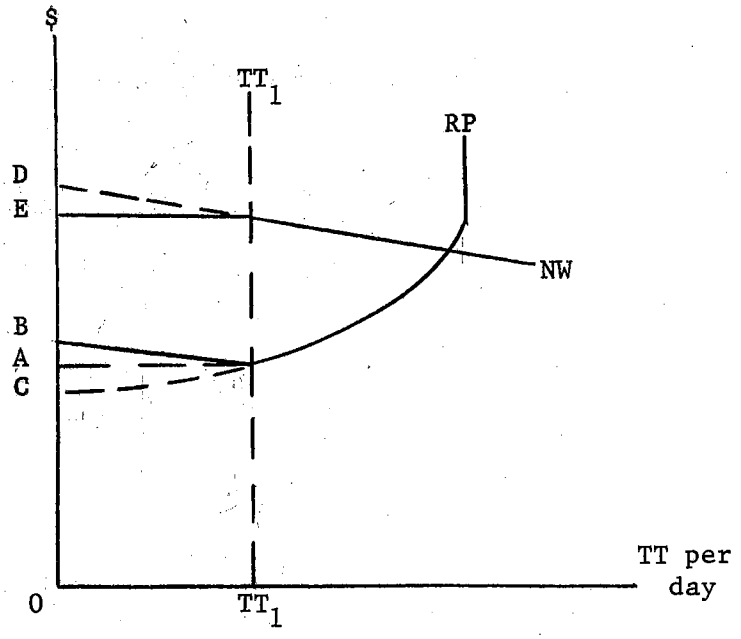

Figure 19

The dollar value OB - OC is equal to the dollar value OB - OA of Figure 18. Thus by incorporating the equilibrium differentials in rent into the analysis, the net wage curve becomes perfectly elastic and the residential preference curve becomes negatively inclined between the origin and travel time TT_1. The dollar value represented by (OD - OE) + (OB - OC) is equal to the equilibrium differential in rent shown in Figure 18 of (OD - OC) + (OB - OA) dollars.

The foregoing differences in the price (rent) of residential property between spatial locations are synonymous with differences in the

cost of living. In the earlier discussion of the net wage it was concluded that the cost of living would affect the net wage. However, it was also stated that for the theory of local labor market delimitation variations in the cost of living would be assumed to be non-existent. This assumption in turn excludes from the analysis the complexities introduced by complete utilization of space. However the foregoing discussion of this problem was incorporated in an endeavor to demonstrate that the elimination of this assumption does not alter the validity of the theory of local labor market delimitation. Further, the discussion provided a demonstration of the flexibility and usefulness of the net wage function and the residential preference function as analytical tools.

CHAPTER VI

THE INTRODUCTION OF A CONTIGUOUS LOCAL LABOR MARKET AND THE NET WAGE FUNCTION

Up to this point, the analysis has been based upon the assumption that there were no local labor markets contiguous to the one under study. This meant that individuals had no alternative employment opportunities. The task at hand now is to determine what effect the existence of an adjacent local labor market will have upon the net wage function.[1] As indicated in the earlier discussion of the net wage function, a worker residing at a spatial location of equitravel time with respect to two employment centers establishes the point in terms of travel time where the slope of the net wage curve changes. Beyond such a point, as will be shown, the net wage curve ceases to be linear. Such a travel time represents that spatial location beyond which the individual will include in his computation of net costs (C_n) for one firm the travel time that could be eliminated by accepting employment at the closer firm.

Assumptions and a Strategic Relationship

Throughout the following discussion it will be assumed that the

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[1] The introduction of a contiguous local labor market will not affect the residential preference function. If this conclusion is not readily apparent then a rereading of Chapter IV, dealing with the derivation of the residential preference function, is suggested.

residential preference function of each individual involved is such that he is willing to accept employment, given the prevailing net wage function. The net wage is sufficient to induce the individual to sell his labor to at least one of the two firms, given the spatial location of his residence and his residential preference function for that residence.

The length of the normal work day is taken to be eight hours. However, in the analysis to follow it will be assumed that the individual worker can contract to work for more than eight hours a day if he so desires.[2] Thus the value of marginal product of labor, and in turn the daily wage, is based upon an eight hour working day unless otherwise stated.

At this time it is important to recall an earlier discussion and recognize the implications it holds for the current analysis. Figure 20 is constructed upon the assumption that the location of the firm(s) is fixed. Thus the travel time measured on the horizontal axis depicts the spatial location of various residences with respect to the given location of the firm. However, those diagrams depicting the residential preference function of an individual /̄such as Figure 9(b)/̄ are constructed upon the assumption that the spatial location of the firm is variable. In such diagrams the travel time measured on the horizontal axis depicts various spatial locations of the firm with respect to the given location of the residence. Thus, the residential preference function of the individual cannot be depicted in Figure 20. A recognition and continual awareness of this graphic restriction will preclude

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[2]Such action will not alter the worker's travel time nor the shape of the iso-time maps by assumption.

a possible misuse of the residential preference curve and the net wage curve--a misuse which, unless carefully guarded against, is easy to perpetrate.[3]

Implications for the Net Wage Function

The inclusion of travel time in net costs.--Travel time TT_x in Figure 20 represents that residential spatial location that is equidistant between firm I and firm II in terms of travel time. In accordance with the assumption that travel costs vary directly with travel time, the net wage will be identical for such a worker regardless of the firm at which he works, assuming the value of marginal product of labor and thus the wage paid by each firm to be identical. Thus the worker is indifferent between employment at firm I or II. However a worker residing at a spatial location depicted by travel time TT_a, in computing his net wage from employment at firm I, will not only take into account travel costs, given the transportation medium, but also the extra travel time of $2(TT_a - TT_x)$. Thus travel time TT_x represents that point where travel costs cease to be equal to net costs (C_n) in computing the net wage. The individual, residing at the spatial location depicted by travel time TT_a, views travel time $2(TT_a - TT_x)$ as a cost associated with employment at firm I. The loss of leisure time /equal to $2(TT_a - TT_x)$/ by employment at firm I can be avoided by employment at firm II. It is this inclusion of travel time in the computation of net costs that accounts for the non-linear portion of the net wage curve.

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[3] If the reader is still uncertain as to why the residential preference function cannot be incorporated in Figure 20, then a rereading of Chapters III and IV is suggested. In particular see pages 37, 42, 43 and 50.

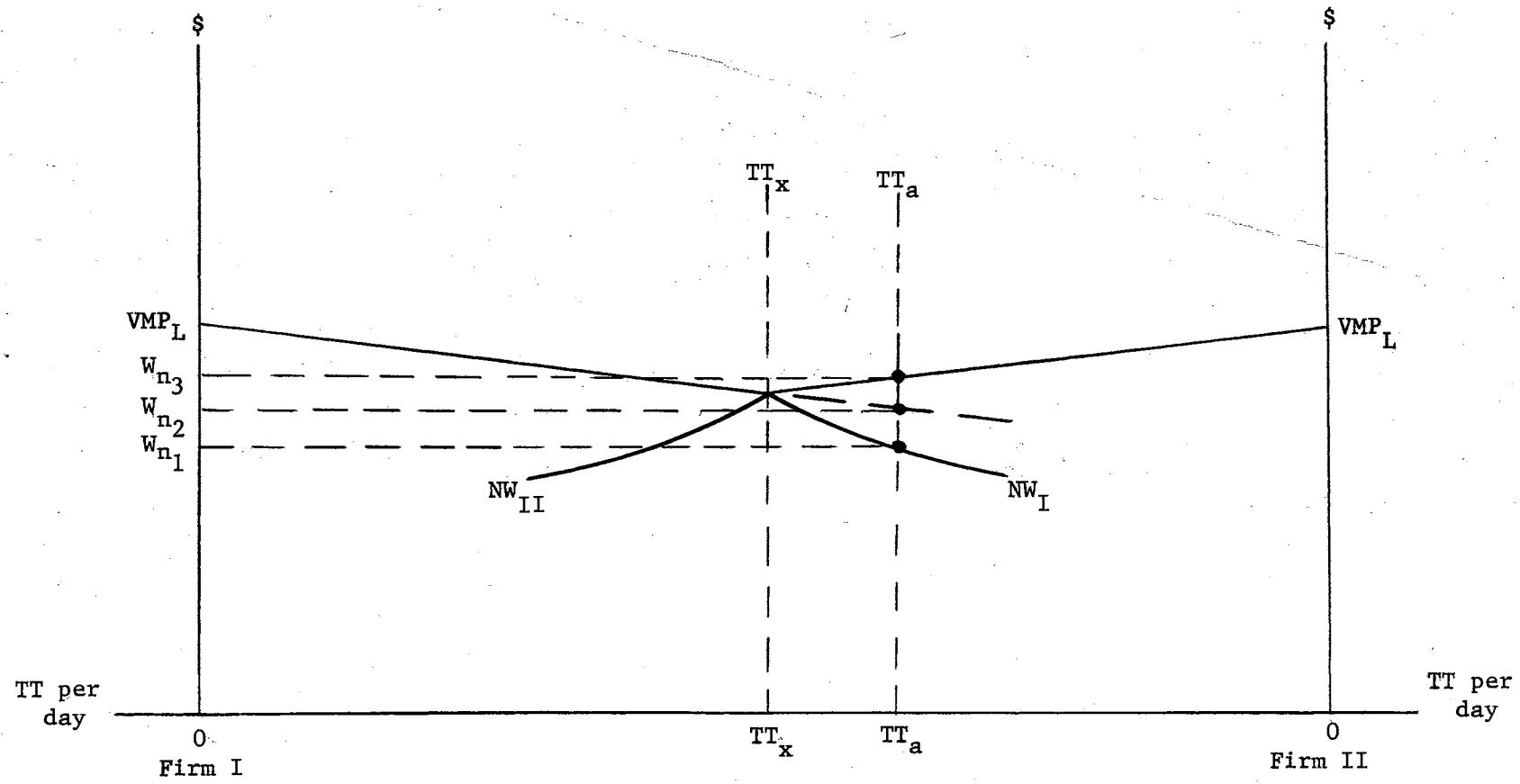
$
$
TT_x
TT_a
VMP_L
W_{n_3}
W_{n_2}
W_{n_1}
NW_{II}
NW_I
VMP_L
TT per day
0
Firm I
TT_x
TT_a
0
Firm II
TT per day

Figure 20

The formula used to derive the decrease in the net wage attributable to that travel time which can be eliminated by employment at the closer firm (in terms of travel time) is:

$$(6.1) \qquad TT_c = \left(\frac{W - C_t}{H} \cdot H \right) - \left(\frac{W - C_t}{H + TT_e} \cdot H \right)$$

Where:

TT_c = travel time costs: the decrease in the net wage attributable to the extra travel time associated with employment at the firm requiring the greater travel time.

W = the wage paid by the firm requiring the greater travel time.

C_t = the travel costs, given the medium of transportation, associated with the firm requiring the greater travel time.

H = the hours of the working day.

TT_e = the extra travel time associated with employment at the firm requiring the greater travel time (the extent to which travel time could be reduced by employment at the firm requiring the smaller travel time).

The following simple arithmetic example should facilitate an understanding of the foregoing formula (6.1). Let:

W = \$20.00 per day

C_t = 4.00 per day

H = 8 hours per day

TT_e = 1 hour per day.

A substitution of these values into equation (6.1) yields:

$$TT_c = \left(\frac{\$20.00 - \$4.00}{8} \cdot 8 \right) - \left(\frac{\$20.00 - \$4.00}{8 + 1} \cdot 8 \right)$$

$$TT_c = \$16.00 - \$14.22$$

$$TT_c = \$1.78.$$

For the worker residing at travel time TT_a in Figure 20, the variables of formula (6.1), for employment at firm I, take on the

following graphic or numerical values:

$$W = VMP_L$$

$$C_t = VMP_L - W_{n_2}$$

$$H = 8 \text{ hours}$$

$$TT_e = 2(TT_a - TT_x)$$

A substitution of these graphic and numerical values into equation (6.1) yields:

$$TT_c = \left[\frac{VMP_L - (VMP_L - W_{n_2})}{8} \cdot 8 \right] - \left[\frac{VMP_L - (VMP_L - W_{n_2})}{8 + 2(TT_a - TT_x)} \cdot 8 \right]$$

$$TT_c = W_{n_2} - \frac{W_{n_2}}{8 + 2(TT_a - TT_x)} \cdot 8$$

or

$$TT_c = W_{n_2} - W_{n_1}.$$

Subtracting $W_{n_2} - W_{n_1}$ from the wage paid by the firm less travel costs associated with travel time $TT_a(W_{n_2})$ yields the net wage resulting from employment at firm I. The result so obtained for travel time TT_a establishes one point on the net wage curve for firm I. In a similar manner a second point on the net wage curve to the right of travel time TT_x can be derived. Repeating this process for an infinite number of travel times to the right of TT_x generates the corresponding portion of the firm's net wage curve. That portion of the net wage curve which is non-linear includes travel time as a component of net costs.

By selling his labor to firm II rather than firm I, the individual residing at spatial location TT_a will increase his net wage by amount $W_{n_3} - W_{n_1}$, so long as the value of marginal product of labor for both firms is VMP_L (as shown in Figure 20). The increase in the net wage can be divided into two parts: (1) that attributable to reduced travel

costs of $W_{n_3} - W_{n_2}$, and (2) that attributable to reduced travel time costs of $W_{n_2} - W_{n_1}$. Thus the individual residing TT_a units of travel time from the firm will maximize his net wage by selling his labor to firm II.

It is now appropriate to briefly set forth the implications of the foregoing discussion for the mathematical treatment accorded the net wage function in Chapter III.[4] As previously stated, the form of the equation representing the net wage function assuming no contiguous local labor markets is (3.7):

$$W_n = W - b(TT).$$

With the introduction of contiguous local labor markets, the individual also takes into account travel time that could be eliminated by altering place of employment in computing his net wage, as set forth by equation (6.1). From equations (3.7) and (6.1) the net wage equation assumes the following form:

(6.2) $$W_n = W - b(TT) - TT_c.$$

An identity exists between the following components of equations (3.7) and (6.1):

(6.3) $$W - b(TT) \equiv \left(\frac{W - C_t}{H} \cdot H \right).$$

Therefore, equation (6.1) can be restated as follows:

(6.4) $$TT_c = \left[W - b(TT) \right] - \left[\frac{W - b(TT)}{H + TT_e} \cdot H \right].$$

From equations (6.2) and (6.4) the equation representing the form of the net wage function also can be expressed as follows:

(6.5) $$W_n = W - b(TT) - \left\{ \left[W - b(TT) \right] - \left[\frac{W - b(TT)}{H + TT_e} \cdot H \right] \right\}.$$

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[4] See pages: 41, 42.

Simplifying equation (6.5) yields:

(6.6) $$W_n = \frac{W - b(TT)}{H + TT_e} \cdot H .$$

Thus equation (6.6), which takes into account the existence of contiguous local labor markets, represents the form of the net wage function for the theory of local labor market delimitation.

By inserting in equation (6.6) travel time (TT) and travel time that could be eliminated by employment at a closer firm (TT_e) for alternative residential spatial locations on the given vector, the net wage associated with each of these locations is derived. From the results so obtained, a graph of the net wage function can be drawn. Its appearance will be similar to the net wage curve labeled NW_I in Figure 20. So long as TT_e is zero the graph of the function is linear; however when TT_e is greater than zero the graph of the function is non-linear.

Table 5 and Figure 21 provide an arithmetic illustration of the inclusion of travel time in net costs (C_n) and its implications for the net wage function. In Table 5 the computation of the net wage associated with employment at firm I for spatial locations A, B, C, D, E, F, G and H is set forth. By repeating the process for an infinite number of spatial locations the net wage curve for firm I is derived. The curve labeled NW_{I_1} in Figure 21 is such a curve. Spatial locations A through H are shown thereon. The points labeled C', D', E', F', G' and H' represent the decrease in the wage attributable to travel costs (C_t) only. Curve NW_{II_1} represents only the linear portion of the net wage curve for firm II. The linear curve labeled NW_{II_2} should be disregarded for the present. It will be utilized at a later stage of analysis.

Given the value of marginal product of labor of fourteen dollars per day, a per hourly cost of travel time of one dollar (b = 1), and

TABLE 5

A HYPOTHETICAL NET WAGE SCHEDULE FOR FIRM I

(1) Spatial Location	(2) Wage (W)	(3) Travel Costs (C_t)	(4) Extra Travel Time (TT_e)	(5) Travel Time Costs (TT_c)	(6) Net Wage (Col 2) - (Col's 3 & 4)
A	$14.00	$3.00	0	$0.00	$11.00
B	14.00	4.00	0	0.00	10.00
C	14.00	4.25	½ hour	0.57	9.18
D	14.00	4.50	1 hour	1.05	8.45
E	14.00	4.75	1½ hours	1.46	7.79
F	14.00	5.00	2 hours	1.80	7.20
G	14.00	5.25	2½ hours	2.09	6.66
H	14.00	5.50	3 hours	2.32	6.18

the spatial location of firm II with respect to firm I (in terms of travel time), the net wage curve for firm I is linear between zero and four hours of travel time. However, when travel time exceeds four hours

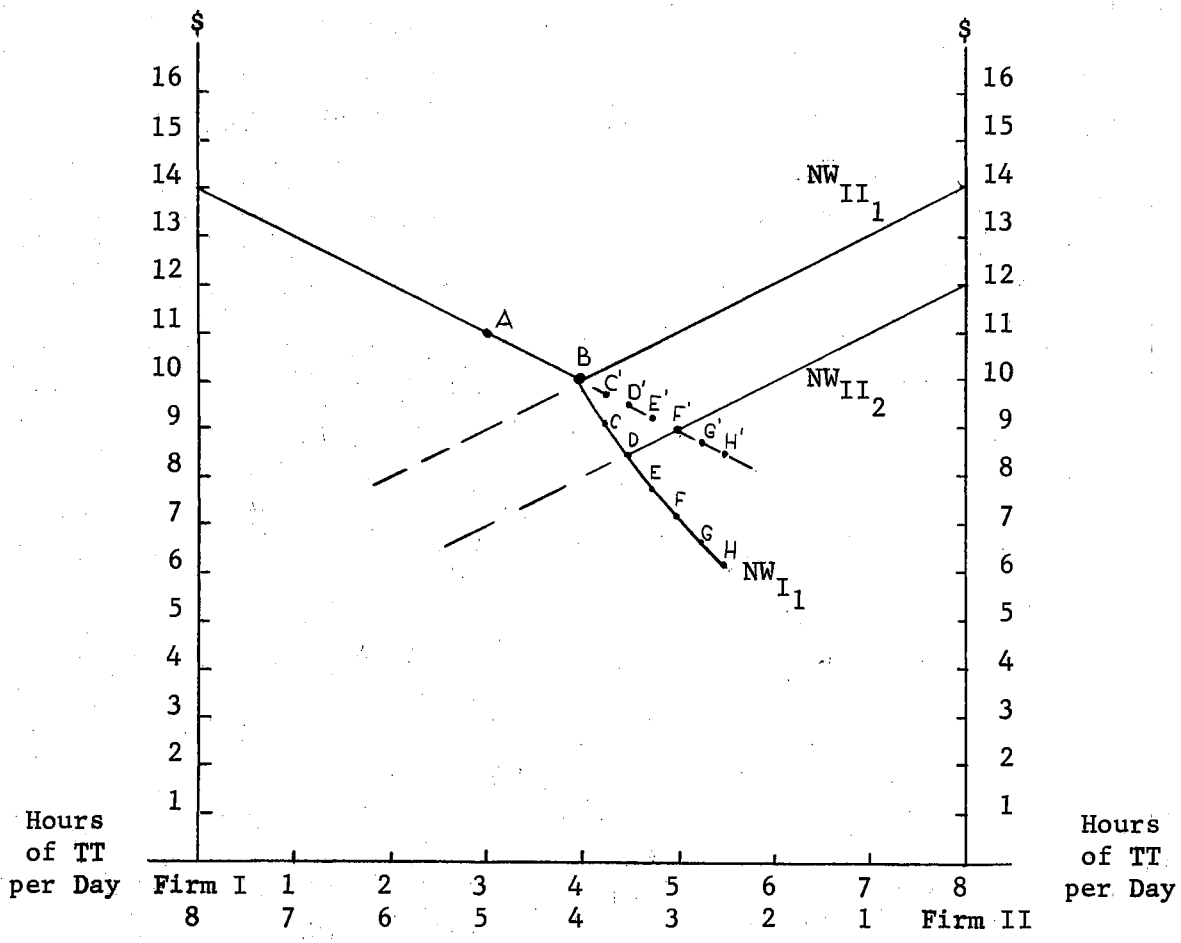

Figure 21

the net wage curve becomes non-linear. From the point of inflection, represented by spatial location B, the curve becomes convex with respect to the origin (representing firm I). This convexity conforms with the data appearing in column 5 of Table 5: travel time costs are increasing at a decreasing rate.

Relationship to the residential preference function.--The decrease in the net wage, incorporated into the net wage function, due to the

inclusion of travel time in net costs must not be confused with the marginal rate of substitution of income for leisure time. This later relationship, as will be recalled, is incorporated into the individual's residential preference function. Figure 22 shows the residential preference curve of the individual residing at travel time TT_a in Figure 20. Thus in Figure 22 the location of firm I with respect to the residence

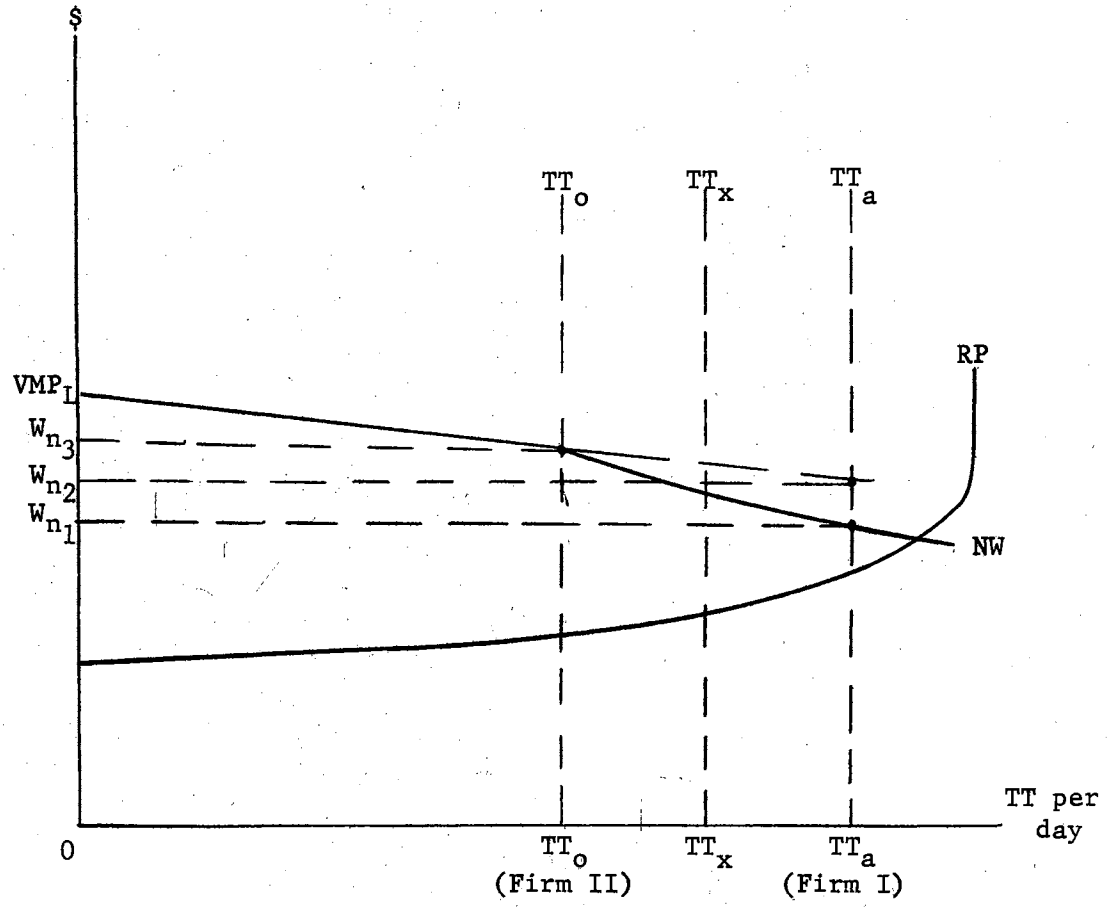

Figure 22

is depicted by travel time TT_a. In turn the location of firm II is represented by travel time TT_o. Travel time TT_x is the same for both Figure 20 and Figure 22. A comparison of the net wage curve and the residential preference curve indicates that the individual would sell

his labor to either firm rather than withhold his services from the market, since the net wage associated with employment at firm I exceeds that necessary to induce the individual to sell his labor. An examination of Figure 22 reveals results identical to those yielded by Figure 20. By working at firm II rather than firm I, the individual can increase his net wage by $W_{n_3} - W_{n_1}$, which is identical to the figure derived from Figure 20. In turn the components of this increase are identical to those previously computed: (1) $W_{n_3} - W_{n_2}$ due to the reduction in travel costs, and (2) $W_{n_2} - W_{n_1}$ due to the reduction in travel time costs.

A Shift in the Net Wage Function

The foregoing discussion should not be interpreted as meaning that the individual residing at travel time TT_a will always sell his labor to firm II. For example, assume that the value of marginal product of labor increases at firm I and thus the wage paid by the firm (which indicates that long-run equilibrium does not prevail). This causes the net wage curve for firm I to shift upward, ceteris paribus. In Figure 23 this is represented by the shift in the net wage curve from NW_{I_1} to NW_{I_2}. In such a case the individual residing at travel time TT_a would maximize his net wage by selling his labor to firm I rather than firm II given the strength of his tastes and preferences for his current place of residence. Such a case, as will be demonstrated more rigorously at a later stage of analysis, is limited to the short run.

Figure 21 provides an arithmetic illustration of a downward shift in the net wage curve. Assume the wage paid by firm II falls by two dollars per day, from fourteen dollars to twelve dollars. This shifts the linear portion of the net wage curve for firm II downward from NW_{II_1} to NW_{II_2}. As a result of this shift, the point of intersection of the

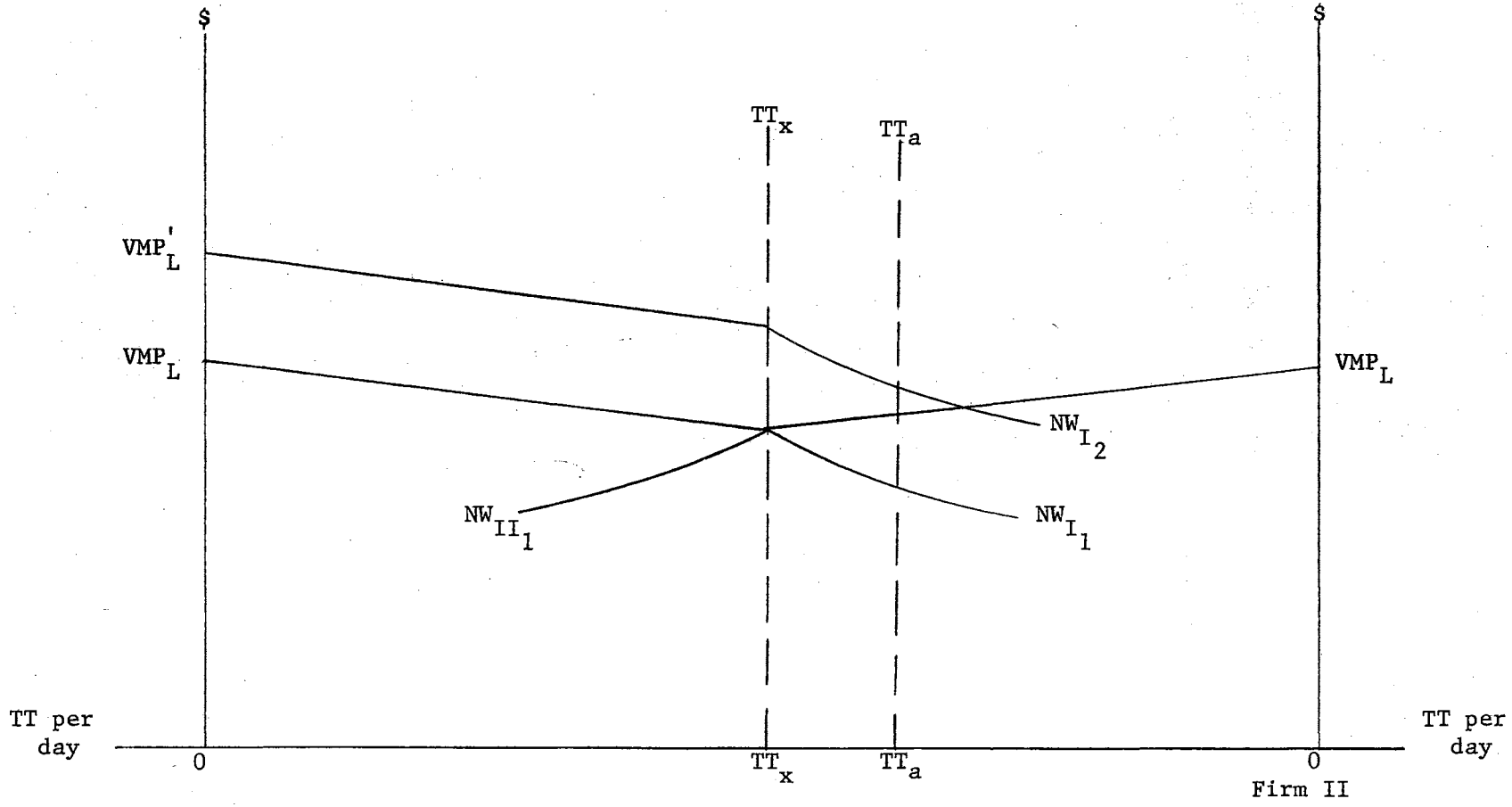
$
$
TT_x
TT_a
VMP'_L
VMP_L
VMP_L
NW_I2
NW_II1
NW_I1
TT per day
0
TT_x
TT_a
0
Firm II
TT per day

Figure 23

two net wage curves is represented by point D rather than point B. Thus point D represents the spatial location at which a worker would be indifferent between employment at firm I or II. The numerical values appearing along the two axes of Figure 21 provide a means of verification. By working at firm I the individual residing at spatial location D will have $9.50 left after deducting travel costs. However, employment at firm I involves one more hour of travel time than employment at firm II. By working an additional hour each day at firm I the individual could also earn $9.50 per day less travel expenses. Thus a worker residing at spatial location D is indifferent between employment at firm I or II, given a value of marginal product of labor of fourteen dollars per day at firm I and twelve dollars per day at firm II.[5]

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[5]Given the above values the precise point of intersection of the two net wage curves is at a travel time immediately to the left of that corresponding to point D. For purposes of graphic simplicity, however, point D is taken to represent the point of intersection.

CHAPTER VII

THE DELIMITATION OF LOCAL LABOR MARKETS AND THE CONDITIONS FOR LONG-RUN EQUILIBRIUM

The previous chapters provide the analytical foundation for the theory of local labor market delimitation. Two major objectives were sought in developing this foundation material. The first objective was to introduce, define, derive and illustrate the iso-time curve, the net wage function and the residential preference function; and to indicate, where applicable, the interrelationships between these new analytical tools. A second objective was to depict the compatibility between these new tools of analysis and orthodox economic theory, since the theory of local labor market delimitation is an extension and not a contradiction of traditional economic principles. As such it affords, in the author's opinion, another demonstration of the usefulness, flexibility and dynamic nature of economic theory. The new tools of analysis are in reality no more than mere restatements of established economic principles in different form--restatements that facilitate the incorporation and explanation of spatial phenomena into economic analysis. Given the analytical foundation developed in the preceding chapters it is now possible to construct a simple model depicting the delimitation of local labor markets.

The theory of local labor market delimitation can be illustrated most effectively by a simple model employing iso-time curves. The delimitation of the local labor markets yielded by the iso-time model

will in turn be subjected to analytical verification through the employment of that tool designated as the net wage function. From this process the conditions deemed essential for long run local labor market equilibrium, ceteris paribus, will be derived. Then in the next chapter an endeavor will be made to determine whether or not the equilibrium is stable or unstable. This will be accomplished by disturbing equilibrium and then observing if forces automatically come into play to re-establish long-run local labor market equilibrium. The conditions essential for short-run local labor market equilibrium are reserved for discussion in the next chapter where the short-run problem logically develops. Thus it must be kept in mind that this chapter is devoted exclusively to long-run local labor market equilibrium.

A Model of Local Labor Market Delimitation

The assumptions.--The model used to illustrate the delimitation of local labor markets consists of three employment centers. The spatial location of these three centers, designated I, II, and III, and the system of iso-time curves for each are shown in Figure 24. Eight major assumptions govern the model. Each of the eight will be discussed individually. This procedure serves a two-fold purpose. In the first instance, it tends to fix firmly in mind those factors to be held constant. One must continually be aware that changes in any of these factors will affect the analysis. In the second instance, this procedure provides a partial summary of the material previously developed. Such a review will facilitate the analysis of this chapter, since the concepts developed in the previous chapters provide the analytical foundation essential for the delimitation of local labor markets. The discussion

of each major assumption follows.

1. Pure competition prevails. The definition of pure competition varies slightly among authors.[1] The concept of the term as used herein conforms with generally accepted definitions except in those instances where perfect mobility of labor is assumed. In the theory of local labor market delimitation, pure competition does not imply perfect mobility of labor. The restrictions on labor mobility stem from the introduction of tastes and preferences for place of residence. Labor mobility varies inversely with the strength of an individual's tastes and preferences for place of residence. Thus different individuals possess different degrees of mobility. An individual whose tastes and preferences for his place of residence are quite weak will be more mobile than an individual whose tastes and preferences are quite strong. The strength of tastes and preferences for place of residence are depicted analytically by the individual's residential preference function. The further an individual's residential preference function extends to the right the greater the strength of tastes and preferences for place of residence (see Figure 11).

The exclusion of perfect labor mobility from the definition of pure competition must not be construed as implying that labor mobility is completely precluded. To the contrary, it is the migration of labor (and capital) that moves a system of local labor markets toward equilibrium. Therefore, a key task for the theory of local labor market

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[1]For examples of these variations an examination of the following books is suggested. M. M. Bober, Intermediate Price and Income Theory (New York, 1955), pp. 166-169. Richard H. Leftwich, The Price System and Resource Allocation (New York, 1955), pp. 23-25. George J. Stigler, The Theory of Competitive Price (New York, 1946), pp. 21-24.

delimitation is to explain the economic process by which mobility occurs rather than to simply assume that it does occur. An understanding of this process is essential for the delimitation of local labor markets. Thus for purposes of the theory of local labor market delimitation, pure competition is viewed simply as a condition where homogeneous products are being produced by such a large number of firms that no one firm has any effect on product or resource prices; nor does any one resource owner supply enough of a given resource to influence its price.

2. Outside of the given centers of employment no job opportunities exist. This assumption stems from a desire to simplify the analysis. It facilitates the isolation of key variables and their direction of movement. The concept of employment centers, composed of many firms, is necessitated by the previous assumption of pure competition.[2] Each center is assumed to produce a different product. However, the firms within a given center are assumed to produce a homogeneous product. Further, there are assumed to be a sufficient number of firms in each center to preclude any one firm from having any effect on price in either the product market or resource market. It is also assumed that the location of individual firms within a center creates no variations in travel time. That is, given the spatial location of an individual's residence, the travel time to any one of the firms within a center will be identical.[3] This is accomplished via the assumption that all workers

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[2]The definition of an iso-time curve, set forth in Chapter II, was constructed so as to include the utilization of employment centers. Thus the use of this concept, rather than an individual firm, creates no definitional inconsistencies.

[3]This assumption has its counterpart in reality. It is similar to those situations on Manhattan Island, New York, where numerous garment manufacturers are housed in a single building having the appearance of an office structure.

park in one large lot adjacent to the complex of firms, as would be the case if the workers were employed by one large firm.[4]

3. The value of marginal product of labor, as well as the value of marginal product of capital, is the same in each employment center. Economic theory tells one that long-run equilibrium prevails when all resources are allocated so that the value of marginal product of each resource is the same among alternative employments. Although these two conditions are essential for long-run local labor market equilibrium they are not sufficient conditions. A third condition will be introduced in this chapter. To facilitate the introduction of this third condition, the foregoing two essential but not sufficient conditions for long-run local labor market equilibrium are assumed to prevail. In the chapter to follow, however, this restrictive assumption will be eliminated.

4. Travel costs vary directly with travel time. Given the medium of transportation, travel costs incurred in going to and from work each day are assumed to be a function of travel time. The greater the travel time the greater the travel costs. Thus the net wage is derived by subtracting travel costs from the wage paid by the firm up to some point in time. Beyond such a point, however, travel time that could be eliminated by accepting employment at an alternative center will be incorporated into the computation of net costs and thus the determination of the net wage. The locus of points representing the net wage so derived for each possible travel time, with respect to a given employment center, is that center's net wage curve. The curve slopes downward to the right

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[4] An example from the industrial world is provided by the Oklahoma City Air Materiel Area, Oklahoma City, Oklahoma, which employs approximately 19,000 individuals. The majority of these employees park in a large lot paralleling the east side of the main plant.

indicating that as travel time increases the net wage decreases. The curve is assumed to be linear throughout some range of travel time. Beyond some travel time, however, it becomes non-linear. The net wage curve, for a given employment center, becomes non-linear when travel time to that center initially exceeds that associated with another center. For a given vector, it is the spatial location where individuals initially include travel time that could be eliminated by alternative employment in the computation of net costs. The given medium of transportation, in conformity with the assumption set forth in Chapter II, is the automobile.

5. The condition, type and routing of roads and traffic congestion are taken as given. However, terrain barriers that result in discontinuous iso-time curves or isolated pockets of iso-time curves are assumed to be non-existent. Given the automobile as the medium of transportation, travel time is a function of the pattern and quality of highway facilities, terrain, population density and traffic flows. By taking these determinants as given, travel time becomes a constant. Thus the three systems of iso-time curves shown in Figure 24 will remain unaltered throughout the analysis undertaken in this chapter. However in the next chapter this assumption will be relaxed, and changes in highway facilities will be introduced. Such changes, as will be shown, not only alter the system of iso-time curves but the delimitation of local labor markets as well.

6. Tastes and preferences of individuals for their residential location are taken as given. An individual's tastes and preferences for place of residence are depicted analytically by the residential preference function. Given the individual's tastes and preferences for his current

place of residence, this function indicates that net wage, for each possible travel time, which is just sufficient to induce the individual to sell his labor to the firm. The curve slopes upward and to the right indicating a direct relationship between travel time and the net wage. The greater the travel time the greater will be the required net wage. So long as travel time is equal to or less than that indicated by the intersection of the net wage curve and the residential preference curve, the individual will be willing to sell his labor to the firm. Beyond some point, however, the residential preference curve becomes completely insensitive to the net wage. Thus a maximum limit is placed upon the geographical extent of a given local labor market.[5]

Although tastes and preferences for place of residence are taken as given, it must be recognized that variations in this factor would affect the analysis. For example a given proportional decline in the strength of such preferences for every individual will tend to reduce the maximum possible geographic extent of the local labor market; whereas an increase would tend to expand its ultimate geographic extent.

7. Individuals travel those routes that minimize travel time. This assumption in turn rests upon the assumption of rational action. If individuals act rationally they will travel those routes that minimize travel time and thus travel costs. Given the individual's tastes and preferences for his place of residence, such action will maximize the net wage, or, in slightly different terms, minimize the sacrifices incurred by the individual in continuing to live at his

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[5]For a detailed discussion of this concept see pages 61-65.

place of residence. Thus the selection of any other route of travel would constitute irrational action.

8. The cost of living is identical for all spatial locations. This assumption stems from a desire to achieve simplicity of analysis. Since variations in the cost of living tend to complicate the analysis they are assumed away. This procedure facilitates the isolation of key variables and their direction of movement. However, the elimination of this assumption would not affect the validity of the theory of local labor market delimitation as indicated in previous discussions.

Delimitation of the markets.--Given the foregoing assumptions, the locus of points generated by the intersection and tangency of equal iso-time curves (of different systems) delimits local labor markets in the long run. The curves labeled BL (boundary line) in Figure 24 are so constructed. They connect those spatial locations that are of equal travel time with respect to two or more employment centers. Spatial locations A, C, D and E provide an illustration. Spatial location A is 5 units of travel time from either center I or II. Spatial location C is 6 units of travel time from all three centers. Spatial location D is 5 units of travel time from center II and center III. Spatial location E is 5 units of travel time from either center III or I. Thus spatial locations A, C, D and E each lie on one of the curves delimiting local labor markets I, II and III from one another.

A worker residing at a spatial location on a BL curve would be indifferent between employment at the centers so separated, since travel costs and travel time associated with employment at such centers are identical. For example an individual residing at spatial location A would be indifferent between employment at centers I or II. His costs

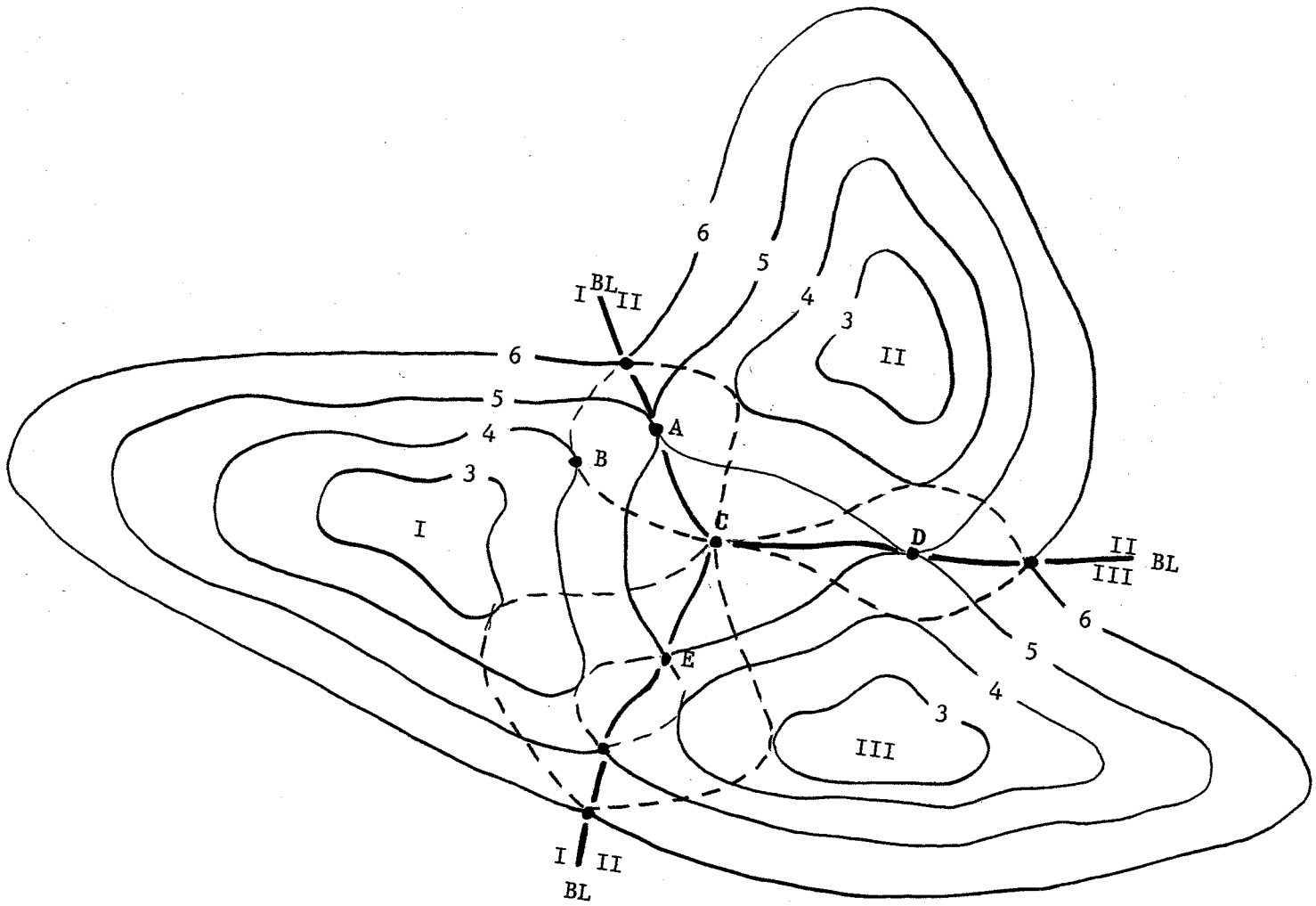

Figure 24

of travel to and from work as well as the travel time required (5 units) would be identical regardless of whether he worked at center I or center II. However a worker residing at spatial location B would work at center I as travel time and travel costs would be less. On the other hand a worker residing at a spatial location to the right of the BL curve separating markets I and II and above the BL curve separating markets II and III will work at center II as travel costs and travel time will be minimized.

In the long run the place of employment of all workers will be such that the BL curves in Figure 24 will delimit the three local labor markets from each other. All workers residing to the left of the I I boundary will be employed at center I. All workers residing above (or to the right of) the II II boundary will be employed at center II. In turn all workers residing below (or to the right of) the III III curve will be employed at center III. Given the eight key assumptions upon which the model is built, the foregoing condition indicates that all workers are minimizing travel costs and travel time. Thus there is no incentive for workers to alter their place of employment, ceteris paribus. Long-run local labor market equilibrium prevails.

Analytical verification with the net wage function.--The foregoing conclusion, that spatial location A in Figure 24 lies on the boundary line delimiting local labor markets I and II in the long run, can be demonstrated with greater analytical rigor by utilizing the net wage function. The hypothesis to be tested can be stated as follows: that point in space where travel time is identical between two centers of employment constitutes one point on a curve that delimits the two local labor markets in the long run.

In Figure 25 the conditions of the hypothesis are fulfilled by spatial location A. (This is the spatial location that was also designated A in Figure 24.) It is 5 units of travel time from either center of employment. Given the net wage curve for center I, NW_I, and center II, NW_{II}, the net wage yielded by employment at either center will be W_{n_1}. This equality in the net wage indicates that travel costs and travel time associated with employment at either center are identical. Thus an individual residing at spatial location A will be indifferent between employment at center I or II. Given the vector under study, only at spatial location A will the net wage derived from employment at either center be identical. For any spatial location on the vector to the left of A, the net wage associated with employment at center I will exceed that associated with employment at center II. In turn for any spatial location on the vector to the right of A, the net wage associated with employment at center II will exceed that associated with employment at center I. Thus all workers residing at spatial locations to the left of I II will work at center I; whereas all workers residing at spatial locations to the right of I II will work at center II.

Those conclusions can be illustrated more precisely by examining the alternatives open to a worker residing at spatial location B. Employment at center I will yield the individual at spatial location B a net wage of W_{n_2}. On the other hand employment at center II will yield the individual residing at spatial location B a net wage of W_{n_o}. Thus the individual will sell his services to a firm in center I since $W_{n_2} > W_{n_o}$. Any other decision would not be a maximizing one. Thus it is concluded that point A lies on the curve that delimits local labor markets I and II. The results conform with the initial hypothesis.

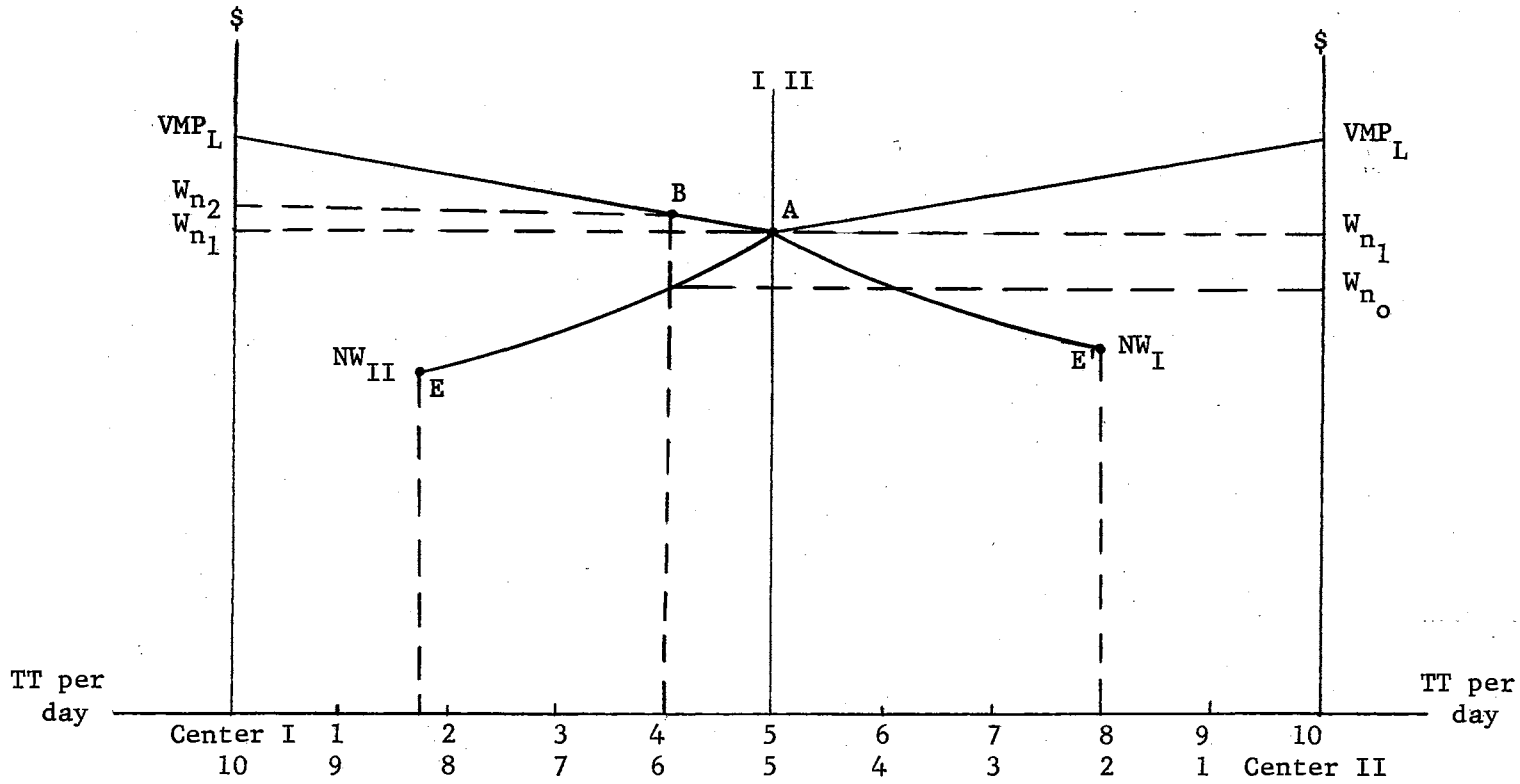
$
VMP_L
W_n2
W_n1
I II
B
A
$
VMP_L
W_n1
W_no
NW_II
E
E'
NW_I
TT per day
TT per day
Center I 10 9 8 7 6 5 4 3 2 1 Center II

Figure 25

The foregoing analysis indicates that the net wage function is a convenient analytical tool for identifying a spatial location that delimits two local labor markets. Thus the intersection of the net wage curves for centers I and II, for a different vector, will yield a second point lying on the curve delimiting the two markets. In turn the intersection of the net wage curves of the two centers for an infinite number of vectors generates a locus of points that delimits the two markets. The curve so generated connects spatial locations that yield a worker an equal net wage regardless of the center of employment. However, the absolute net wage will vary between such spatial locations.[6] Since travel costs are a function of travel time, the net wage yielded by employment at either center will be equal only if travel time is equal. Therefore it is concluded that the intersection and tangency of equal iso-time curves delimit local labor markets in the long run.

Spatial locations E and E' in Figure 25 indicate the maximum possible extent of the respective local labor markets. Individuals residing to the right of E' will not seek employment at center I regardless of the wage paid by the firm. Beyond point E' travel time is completely insensitive to the net wage for all workers. The residential preference curve of the individual with the strongest tastes and preferences for place of residence becomes completely inelastic at 8 units of travel time. However for center II this condition occurs at 8¼ units of travel time. These phenomena are a reflection of the variations in tastes and preferences of individuals for their place of residence.

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[6]For example one spatial location lying on the boundary line may yield a net wage of $15.00 regardless of the center of employment; whereas a second location on the boundary line may yield a net wage of $14.00 regardless of the center of employment.

Conditions of Equilibrium

The foregoing analysis establishes three essential conditions for long-run local labor market equilibrium. These conditions are: (1) the value of marginal product of labor must be equal between centers, (2) the value of marginal product of capital must be equal between centers, and (3) the curve delimiting local labor markets must be the locus of points generated by the tangency and intersection of equal iso-time curves. When these three conditions prevail there will be no incentive for change. Long-run local labor market equilibrium prevails.

CHAPTER VIII

DISTURBANCE AND RE-ESTABLISHMENT OF LOCAL LABOR MARKET EQUILIBRIUM

The purpose of this chapter is to demonstrate that the three conditions for long-run local labor market equilibrium set forth in the previous chapter yield a stable rather than an unstable equilibrium. This will be accomplished by disturbing equilibrium and then identifying those variables and their direction of movement that automatically tend to re-establish equilibrium. The economic process by which equilibrium is re-established will be divided into time periods. Thus the analysis provides a convenient opportunity to set forth simultaneously the conditions necessary for short-run local labor market equilibrium. For purposes of simplicity the analysis is limited to a two-local labor market system. For each local labor market there is one employment center. The two centers of employment are designated I and II.

A Change in the Demand for Products

Assume that a change in consumer tastes and preferences increases the demand for the product produced at employment center I. It also is assumed that the increased demand for the product stems from sources exogenous to the two-local labor market system utilized in this

analysis.[1] Prior to a detailed analysis of the process by which equilibrium is re-established and the accompanying effects upon the spatial aspects of the two local labor markets, it will be advantageous to summarize briefly what economic theory tells one about the forces that automatically come into operation to restore equilibrium.

The price of the product produced in center I rises. Thus employers seek to increase employment.[2] Since by definition entrepreneurs in center I face an upward sloping labor supply curve, a higher wage must be paid to bring forth additional quantities of labor. Thus two major forces come into play to restore equilibrium between the wage rate and the value of marginal product of labor: (1) to secure additional supplies of labor, the wage rate must rise; and (2) as more labor is hired, its value of marginal product declines. In turn, the latter phenomenon can be subdivided into two operations: (a) as more labor is employed, its marginal physical product declines; and (b) as more of the product is produced as a result of the increased employment, the price of center I's product will fall.[3]

As labor leaves center II in response to the higher wage in center I,

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[1]This assumption is selected for its methodological advantages. Since these advantages can be more adequately appraised at a later stage of discussion, they are reserved for footnote 10, page 119.

[2]It is assumed that in the short run the only variable resource is labor. Thus, the value of marginal product of labor curve is the firms demand curve for labor. Therefore, as the price of products rise the demand curve for labor shifts upward and to the right. This causes the value of marginal product of labor to exceed the wage paid by the firm. Thus to maximize profits or minimize losses the firm will seek to employ additional workers.

[3]This latter condition holds since center I produces a sufficient quantity of the product in question to affect its price. This condition also applies to center II: changes in center II's output will alter the price of its product. See page 97 for a description of an employment center.

the marginal physical product of labor in center II ($MPP_{L_{II}}$) increases; and output declines, which causes the price of center II's product (P_{II}) to rise. Thus the value of marginal product of labor ($MPP_{L_{II}} \cdot P_{II}$), and therefore the wage, rises in center II. Short-run equilibrium prevails when labor is allocated between center I and center II so that its value of marginal product is identical in both.

In the long run, capital will migrate from center II to center I.[4] This migration disturbs the short-run equilibrium previously established for the variable resource labor. With the inflow of capital, the marginal physical product of labor, and thus the value of marginal product of labor, increases in center I. The resulting rise in the wage stimulates a further reallocation of labor from center II to center I. As more of center I's product is produced, its price falls, and thus the value of marginal product of both labor and capital. On the other hand, the outflow of resources from center II causes the price of its product to rise, which in turn increases the value of marginal product of labor and capital in center II. This process continues until both labor and capital are allocated between centers I and II so that the value of marginal product of each is the same in both centers.

Definitional concepts.--For purposes of clarity it will be advantageous to divide the sources of labor for a firm in a given local labor market into four categories. By raising wages, a firm can expect to secure additional labor from (1) other firms within the local labor market, (2) the entry into the labor force of additional workers from the given population base of the local labor market--this statement is

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[4]The value of marginal product of capital curve for center I initially shifted upward and to the right in response to the exogenous increase in the demand for the product produced at center I.

based upon the assumption that the supply of labor varies directly with the real wage, (3) the expansion of the geographic limits of the local labor market,[5] and (4) a migration of labor into the local labor market from other local labor markets. The analysis of this chapter is limited to the latter two sources--particularly that stemming from the expansion and contraction of local labor markets. By definition, the first two sources, designated as internal sources for purposes of identification, will be defined as being perfectly wage-inelastic in order to simplify the analysis. Therefore that portion of source (3) attributable to the entry of additional workers into the labor force as a result of a higher wage is also excluded. Further, to achieve a high degree of precision and clarity in isolating effects, the sources of labor available to the complex of firms comprising an employment center will be analyzed in terms of three time periods: (1) the very short run, (2) the short run, and (3) the long run. The three time periods will now be defined.

In the very short run, the supply of labor in local labor markets is perfectly inelastic. Even without the assumption that sources of labor (1) and (2) above are completely wage-inelastic, this interpretation would still approximate reality. It takes time for workers to process their separation from a given employer. For most occupations the customary notice is two weeks. Even unskilled labor hired on an hourly basis will normally complete the day's work prior to changing employers. Thus, the very short run is defined as that time period which precludes labor from altering its place of employment.

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[5]This source includes not only workers that change place of employment to maximize their net wage, given their place of residence, but also workers that now enter the labor force from the given population base of the newly "annexed" area as a result of the higher wage.

The short run is defined as being of sufficient duration to allow workers to change place of employment, given their place of residence. Thus in this time period the supply of labor in local labor markets is less than perfectly inelastic. However, this time period is not of sufficient duration to allow workers to change their place of residence from one local labor market to another.

The long run represents that time period in which mobility of labor exists between local labor markets. Therefore, the supply of labor in local labor markets will be more elastic than in either of the foregoing two time periods.[6]

The very short run.--In accordance with the foregoing assumption that internal sources of labor are completely insensitive to changes in the wage rate, it follows that the initial tendency in this time period will be for wage and profit increases to absorb completely the effects stemming from the increased demand for center I's product.[7] This

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[6]In a given industrial complex, at any given point in time, some portion of the capital stock is ready for replacement. Thus it would be possible to have some degree of capital migration between industrial centers in a relatively short period of time if market conditions warranted. In turn, some labor could migrate between industrial centers in a relatively short period of time if market conditions warranted. On the other hand relatively new capital that is not readily transportable or interchangeable with other industries lengthens considerably the process of capital mobility. In turn, labor that has large investments, relatively speaking, in residential property is less mobile time-wise in changing residence from one local labor market to another. Labor mobility is further retarded if the residence is in a declining economic region where property values are already depressed by the initial outmigration of the more mobile workers. Thus, the restriction of the migration of labor between local labor markets to the long run is analytically parallel to the restriction of the migration of capital to the long run.

[7]In the very short run the supply of labor, by definition, is perfectly inelastic. As shown in Figure 26, prior to the change in tastes and preferences for center I's product, the demand for labor in center I is represented by VMP_{L_1} curve and the equilibrium wage is

tendency is depicted in part in Figure 28 by the rise in the net wage rate from W_1 to W_6 in center I. W_6 represents that wage in the very short run that equates the demand and supply of labor (where $VMP_L = W$).

The short run.--In the short run the divergence of the wage rate between center I and center II creates spatial implications for each center's local labor market. The spatial boundary of the local labor market paying the higher wage will tend to expand at the spatial expense of the adjacent local labor market, ceteris paribus.[8] The process of

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[7] W_1. After the change in consumer tastes and preferences, the increased demand for labor is represented by the curve designated VMP_{L_6}. The increased demand for labor is due to the rise in the price of the product produced in center I and not from a change in the marginal physical product of labor. The increased demand for labor results in the new equilibrium wage of W_6. The level of employment is left unaltered, and thus the output of goods and services, since it is assumed that in the short run or a lesser time period output can vary only with the level of employment.

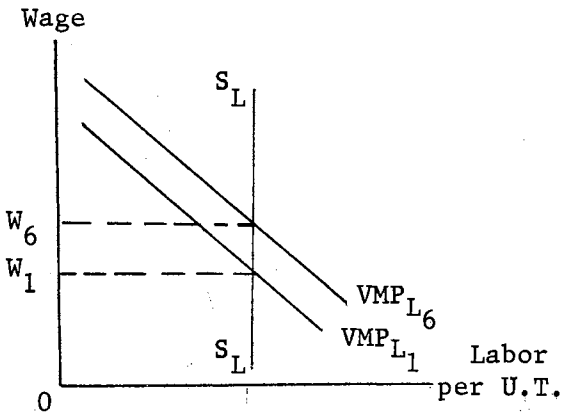

Figure 26

[8] Given a whole system or complex of local labor markets, the spatial expansion of the local labor market offering the higher wage, as the result of an exogenous increase in demand, will not be absorbed solely by adjacent local labor markets in the final analysis. Repercussions upon wage rates paid in adjacent local labor markets will in turn enable them to expand their respective spatial boundaries into labor markets on their periphery. Thus the process of spatial expansion is explosive outward. That is, the repercussion will be felt throughout the entire system of local labor markets given sufficient time. Although the process by which the new local labor market boundaries are established will become clearer in later sections of this chapter, to ensure a clear understanding of the point under discussion, it will be advantageous to depict the results in terms of comparative statics at this time.

A system of local labor markets in long-run equilibrium is depicted, in part, by the solid lines in Figure 27. The boundary between each

labor market expansion and contraction will be demonstrated with the assistance of Figure 28. It should, however, be kept in mind that

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[8] local labor market is the locus of points generated by the tangency and intersection of equal iso-time curves. The dotted lines depict the spatial structure of local labor markets following the completion of short-run readjustments induced by the exogenous change in consumer tastes and preferences that increase demand for center I's product. (As will be emphasized in later discussion, these boundary lines, represented by the dotted curves, do not represent the intersection and tangency of equal iso-time curves.) As indicated, each local labor market tends to shift outward spatially from center I. The core labor market, designated I (in which the wage initially increased) expands its spatial limits outward, thereby increasing the supply of labor available to firms in center I. In turn, the ring of local markets designated II also expands its spatial limits outward (the decrease in output, due to the decline in employment, with demand for the product unchanged, results in a higher value of marginal product of labor which enables the payment of a higher wage), but not sufficiently to avoid a decrease in the supply of labor available in each of its

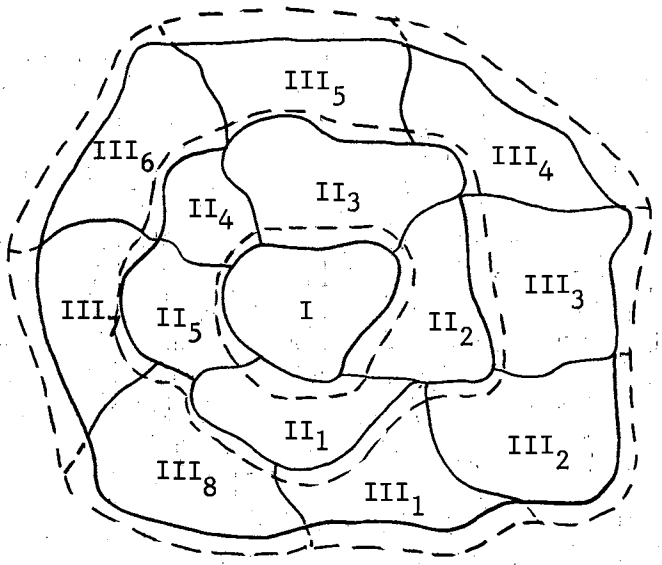

Figure 27

component local labor markets. However, the geographic extent of each local labor market in ring II may either increase, decrease or remain unchanged, depending upon such factors as density of population, transportation facilities and the tastes and preferences of workers for their current place of residence. In turn, the ring of local labor markets designated III also expands its spatial limits outward, but not sufficiently to compensate fully for the loss in its labor supply to the local labor markets comprising ring II. In similar fashion this process is

Figure 28 relates to determining only one point on the curve delimiting local labor markets I and II. However, a repetition of the analysis to follow for an infinite number of vectors would generate the curve delimitating the two markets. In Figure 28 spatial locations, such as D and E, will be located on the diagram in terms of travel time.

With the rise of the wage from W_1 to W_6, the local labor market for center I tends to expand toward spatial location E. For example, as a result of the higher wage a worker residing at spatial location C now finds it advantageous to shift his place of employment from center II to center I. The difference in the two wage rates is not only sufficient to compensate the worker for the extra travel expense, but also more than compensates him for the extra time necessitated in traveling to center I versus center II. Thus, his net wage is greater in center I than in center II. However, as workers leave employment in center II for employment in center I the wage falls in the latter and increases in the former. Therefore, the net wage curve for center I gradually shifts downward while the net wage curve for center II gradually shifts upward. This process continues until point D is reached where the wage is W_4 for center I and W_2 for center II. At this spatial location the higher wage paid in center I will be sufficient to offset exactly the greater opportunity cost of time involved in driving to center I. A worker residing at spatial location D would be indifferent as to

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[8] repeated for each additional ring of local labor markets until eventually reduced to an infinitesimal effect.

In the simplified model used in this chapter, these continuous rings of local labor markets are assumed away in order to reduce the complexities of the analysis and thereby more simply to identify the key variables and their direction of movement.

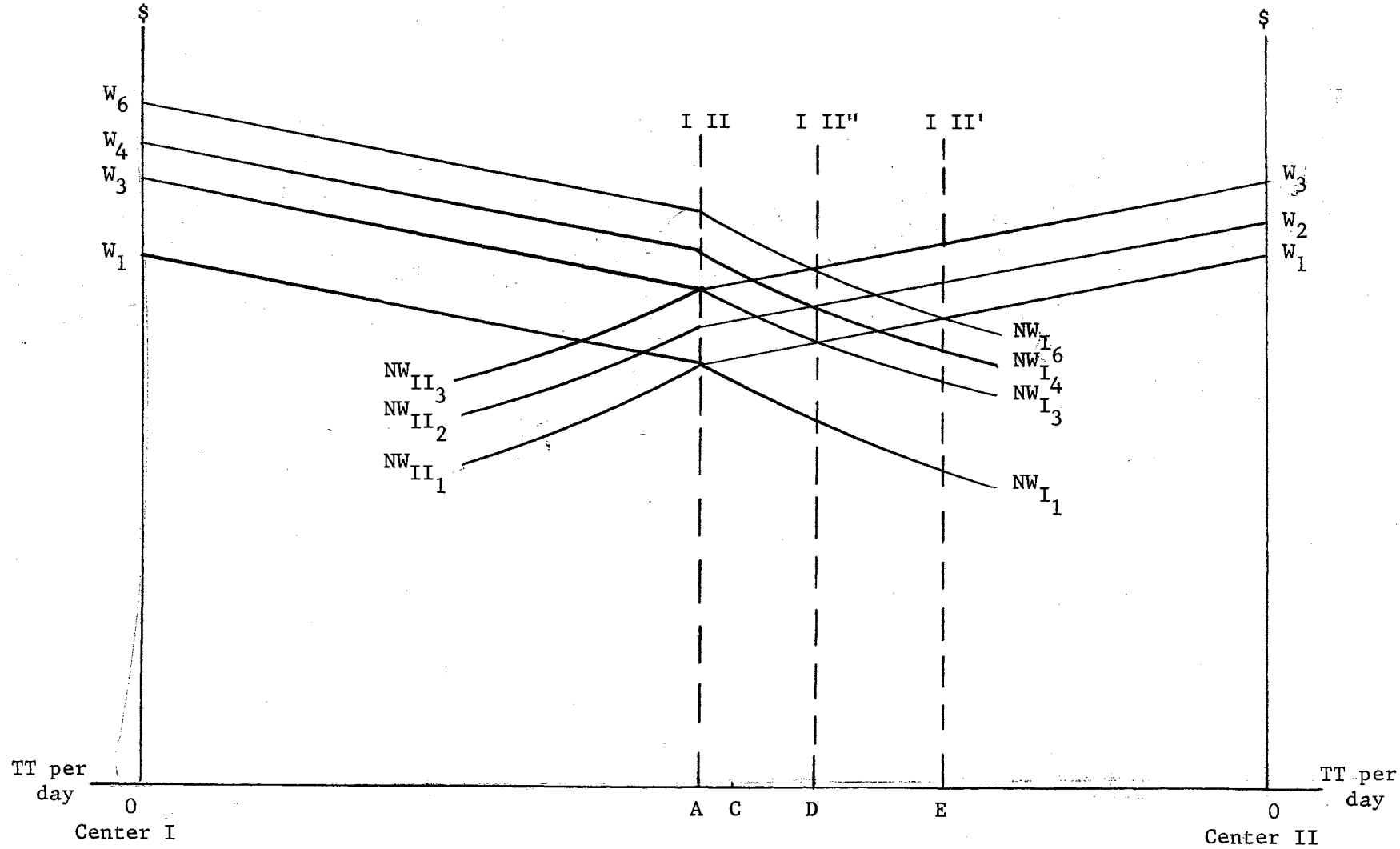
$
$
W6
W4
W3
W1
I II
I II"
I II'
W3
W2
W1
NWI6
NWI4
NWI3
NWII3
NWII2
NWII1
NWI1
TT per day
0
Center I
A
C
D
E
0
Center II
TT per day

Figure 28

whether he worked in center I or center II. Therefore, spatial location D represents one point on the curve delimitating local labor market I from local labor market II in the short run as a result of the change in consumer tastes and preferences that increased the demand for center I's product.

The location of this point relative to point A depicts the extent to which the local labor market has expanded for center I and contracted for center II. OD-OA represents the spatial change that has occurred in terms of travel time. At a spatial short-run equilibrium point such as D, workers cease to change employment between local labor markets. In each local labor market, the wage equals the value of marginal product of labor. However, the value of marginal product of labor, and thus the wage rate, is not equal between the two markets. This latter equality, though essential for long-run local labor market equilibrium, is not a necessary condition for short-run local labor market equilibrium. The bringing into equality of the value of marginal product of labor between the two labor markets must await the coming into play of those automatic forces associated with the long run. However it should be noted that the forces coming into play in the short run tend to reduce the divergence between the value of marginal product of labor in the two markets.

The long run.--The inequality of the value of marginal product of labor between the two local labor markets, represented by wage rates W_4 in center I and W_2 in center II, and the inequality of the value of marginal product of capital between the two centers set in motion long-run equilibrating forces. These forces are: (1) the migration of labor from local labor market II to local labor market I, and (2) the

migration of capital from center II to center I.[9] As labor and capital migrate from local labor market II to local labor market I the value of marginal product of labor and capital decline in center I and rise in center II via product price adjustments. Thus the net wage curve for local labor market I gradually shifts downward while the net wage curve for local labor market II gradually shifts upward. As previously demonstrated, such shifts possess spatial implications for the local labor markets. For local labor market I it means a spatial contraction and for local labor market II a spatial expansion. However the gain in labor supply for market II as a result of the spatial expansion cannot offset the decline in labor supply attributable to outmigration by definition of the directional tendencies required for re-establishment of equilibrium. This process continues until each resource has the same value of marginal product in each employment center. This equality is achieved in Figure 28 at wage rate W_3. At this wage rate the conditions of long-run local labor market equilibrium are fulfilled: (1) labor is allocated between the two markets so that its value of marginal product, and thus its wage, is the same in each; (2) capital (including all fixed resources) is allocated between the two markets in such a manner that its value of marginal product, and thus the return to capital, is the same in each, and (3) the points of tangency and intersection of equal isotime curves generate the boundary line between local labor markets. Workers are neither migrating between local labor markets nor shifting place of employment between centers given their place of residence.

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[9] In the interest of simplicity, the analysis assumes the existence of only the two local labor markets. However, in a system of local labor markets, the migration of labor would tend to come primarily if not entirely from other local labor markets. This point receives additional treatment in footnote 10, page 119.

There is no incentive for resource owners to alter the prevailing spatial pattern of resource (human and nonhuman) employment. Thus long-run local labor market equilibrium prevails.

Although the equilibrium wage rate in both markets is now above that which prevailed prior to the disturbance of equilibrium, the point delimiting local labor market I and II is once again depicted by spatial location A.[10] Thus in the long run the boundary between the two local labor markets is unaltered; however the population base of local labor market I has expanded at the expense of local labor market II. The conclusion that the boundary line between the two local labor markets is unaltered depends upon the assumption that the shift in population between the two markets did not alter the system of iso-time curves for each employment center. If the population shift resulted in a significant

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[10]The higher equilibrium wage is attributable to the assumption that the increase in demand for center I's product came from a source exogenous to our two local labor market model. Thus the increase in demand for center I's product did not alter the demand for center II's product. If it had been assumed that the increase in demand for center I's product could have evolved only from a decrease in demand for center II's product, then the net wage curve for center II would have shifted down initially. As previously implied in footnote 1, page 109, the assumption under discussion was selected in order to provide a convenient and logical means by which to introduce in footnotes some of the additional complexities associated with a system of local labor markets and simultaneously provide less restriction in depicting the directional movement of the various equilibrating variables. Further, in a system of local labor markets the basic source of labor migration would stem from those local labor markets where as a result of the change in consumer tastes and preferences the demand for their products decreased. In such markets the value of marginal product of labor curve would shift downward and to the left, and thereby increase further the leverage for their spatial contraction in the short run and outmigration of labor and capital in the long run. Thus local labor market I in this more complex type of analysis probably would not secure its inmigration of workers at the expense of local labor market II in the final analysis. In the movement toward equilibrium, that portion of market II's labor force migrating to market I would tend to be offset by inmigration from other local labor markets.

change in the pattern of traffic flows and population density, then center I's system of iso-time curves would tend to contract and center II's system of iso-time curves would tend to expand. Therefore, the geographic extent of local labor market II would tend to expand at the expense of local labor market I.[11] Given this case, the new long-run boundary line between the two local labor markets would be different. But more importantly, this analysis demonstrates that a disturbance of local labor market equilibrium attributable to a change in consumer tastes and preferences that increases the demand for the product of a given local labor market automatically sets in motion forces that tend to re-establish equilibrium.

A Change in Highway Facilities

The task at hand is to determine if a disturbance of local labor market equilibrium due to a change in highway facilities (taken as given in the previous analysis) automatically activates forces that tend to re-establish local labor market equilibrium. A two-local labor market world (model) will again be utilized. Also, the previous discussion of sources of labor and time periods is applicable as well as the assumption that in the short run output can vary only with variations in the quantity of labor employed.[12] Figures 29, 30 and 31 assist in the analysis.

As indicated by the iso-time curves in Figure 29, the two local labor markets are in long-run equilibrium: (1) the value of marginal product of labor is equal in each center; (2) the value of marginal

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[11] This conclusion in turn is dependent upon the assumption, set forth in Chapter V, that the complexities introduced by complete utilization of space are nonexistent.

[12] See pages 108-112.

product of capital is equal in each center; and (3) the points of tangency and intersection of equal iso-time curves delimit the two markets as represented by the I II curve. The notable divergence in spatial content of the two local labor markets is assumed to be explainable in terms of terrain and the quality of highway facilities. A portion of the terrain between the two centers is quite hilly and the highway between center I and spatial location M is substandard, two-lane and winding; whereas the highway between spatial location M and center II is modern, divided four-lane and straight. The heavy line connecting centers I and II in Figure 29 represents this highway. A worker residing at spatial location A in Figure 29 would be indifferent between employment at center I or II. Thus, given the above conditions, such a point by definition lies on the I II curve which delimits local labor markets I and II. The symbol B in Figure 31 represents spatial location A of Figure 29 in terms of travel time. At this stage of presentation the only other relevant part of Figure 31 is wage rate W_1 and its associated net wage curves for both centers: NW_{I_1} and NW_{II_1}. The other curves and symbols relate to later analysis.

Now assume that a four-lane divided highway is constructed from center I to spatial location M and that the specifications of this highway are identical to those of the highway from spatial location M to center II. This highway is represented by the heavy line connecting the two centers in Figure 30. Upon the opening of the new highway, the iso-time curves for center I expand outward in the vicinity of the highway. This outward expansion also applies for center II iso-time curves lying to the left of spatial location M. These alterations in the structure of the iso-time map are represented by the dotted lines in

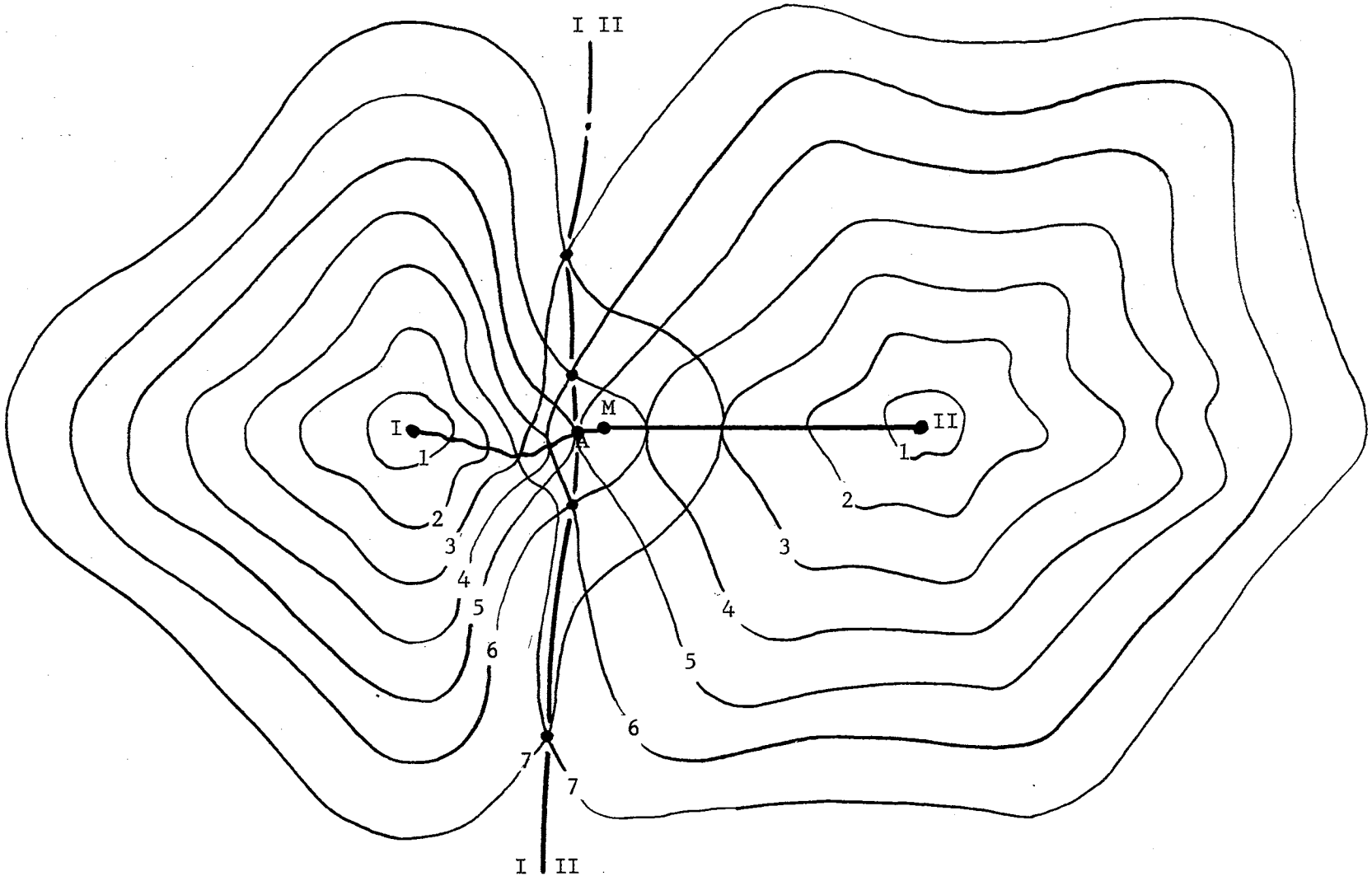


Figure 29

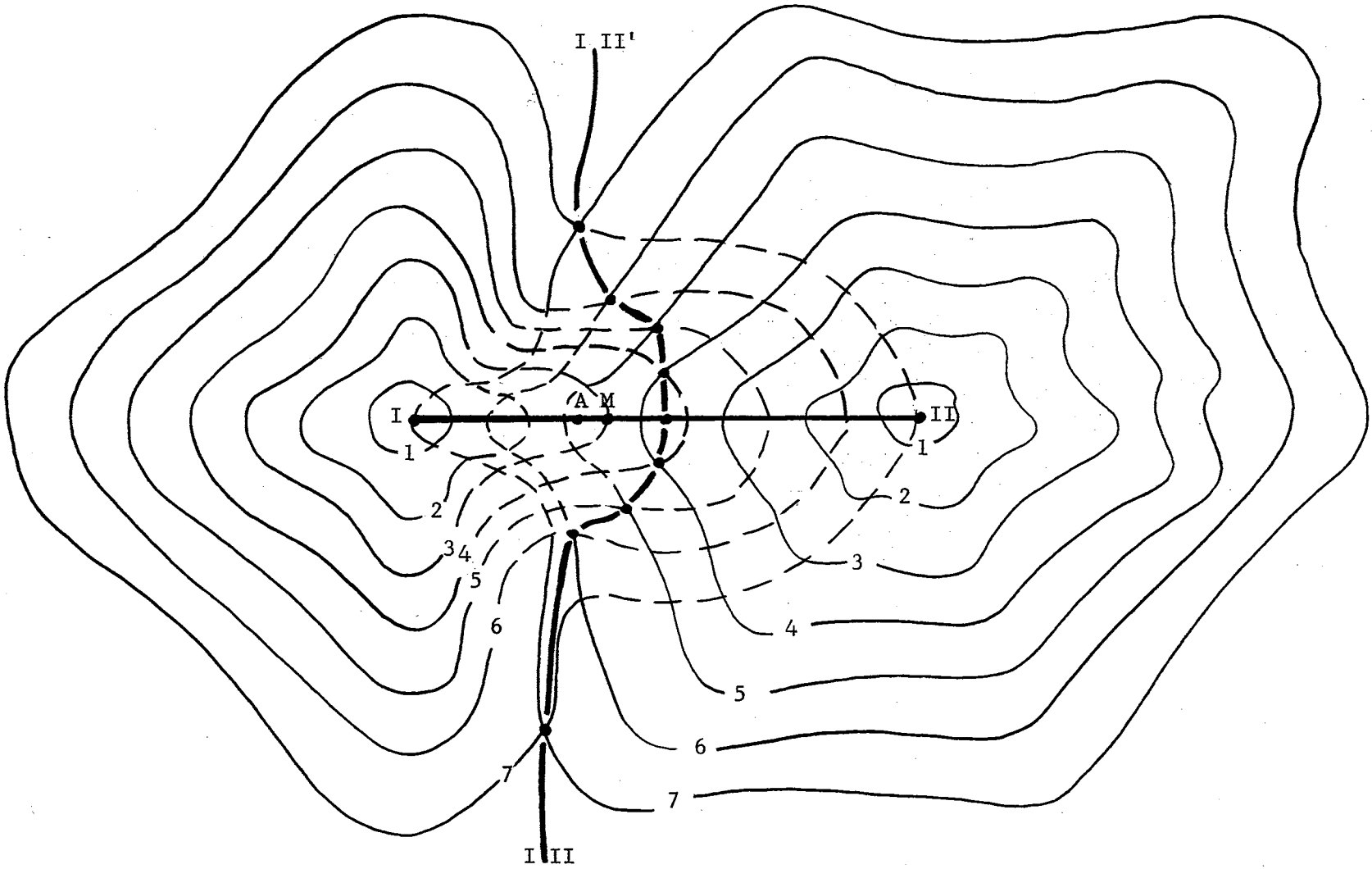
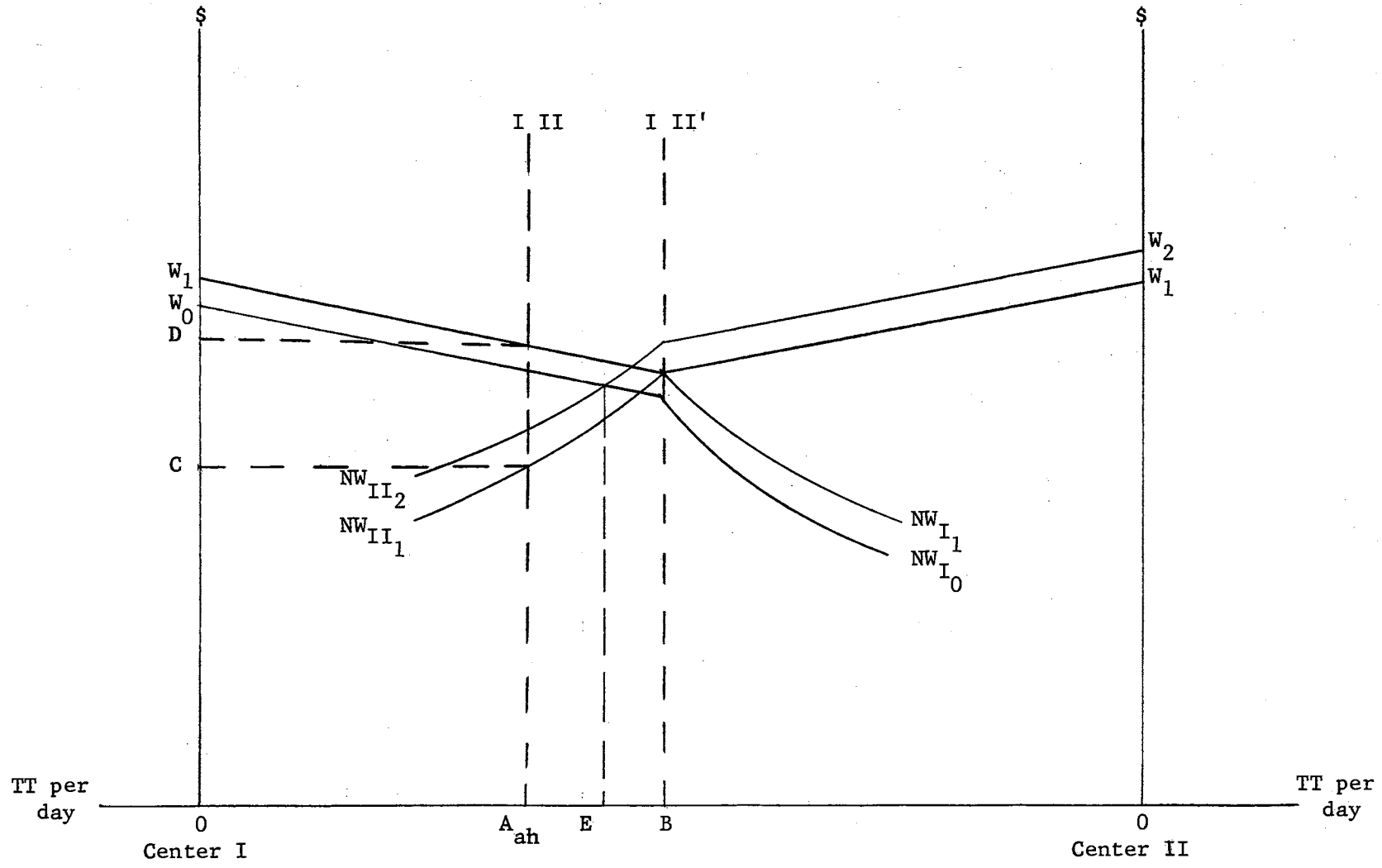


Figure 30


$
$
I II
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W1
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W2
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NWII2
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TT per day
0
Center I
Aah
E
B
0
Center II
TT per day

Figure 31

Figure 30. In Figure 31, which represents only one point on the curve delimiting local labor markets, these alterations are reflected by a leftward shift in the local labor market boundary depicting long-run equilibrium prior to the highway improvement: from I II' to I II. In terms of travel time, spatial location A is now closer to center I than center II. Spatial location A is now represented by A_{ah} and not point B in Figure 31.[13] Thus both Figures 29 and 31 indicate the existence of local labor market disequilibrium. Even though the value of marginal product of labor and the value of marginal product of capital are each the same in both centers, essential but not sufficient conditions for long-run equilibrium, the prevailing curve (I II in Figure 29) delimiting local labor markets is no longer the locus of points generated by the

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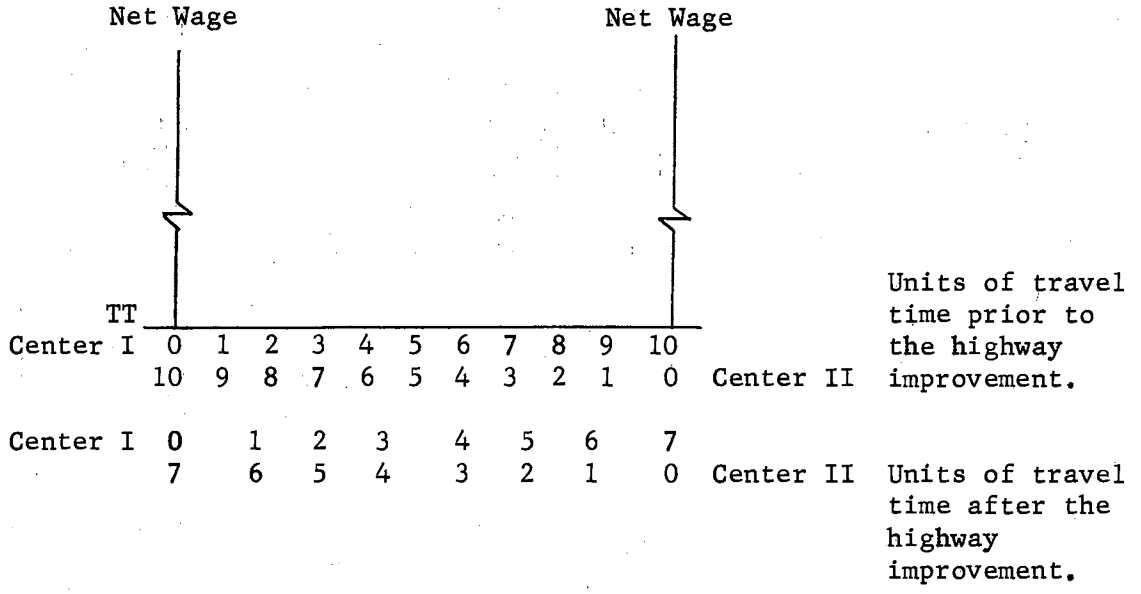
[13]As a result of the highway improvement, the units of travel time measured on the horizontal axis of the net wage diagram will change. For example, prior to the improvement, point B represented five (5) units of travel time whereas after the improvement point B represents approximately three and three-fourths (3 3/4) units of travel time. The full impact of this change is set forth below:



tangency and intersection of equal iso-time curves. The effects of this disequilibrium will now be analyzed in terms of the three time periods.

The very short run.--In the very short run, the change in highway facilities will have no effect. This stems from two conditions. First, the supply of labor is defined as being perfectly inelastic as the time period is of such duration to preclude workers from changing their place of employment. Secondly, the distribution of labor (as well as capital) between centers I and II is such that its value of marginal product is equal in both centers. Thus wages will not change.

The short run.--As a result of the alteration of travel times a worker residing at spatial location A (now represented by A_{ah} in Figure 31) is no longer indifferent between employment in centers I and II. By working in center I his net wage will exceed that of alternative employment in center II by amount OD-OC. Thus workers proceed to shift place of employment from center II to center I, place of residence remaining unaltered. As they change place of employment, the wage paid in center I falls and the wage paid in center II rises. Therefore, the net wage curve for local labor market I gradually shifts downward, and the net wage curve for local labor market II gradually shifts upward.[14] This process continues until point E in Figure 31 is reached representing that spatial location where, in the short run, a worker would be indifferent between employment at centers I and II. In Figure 30,

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[14]The higher wage paid in center II is not solely the result of a decrease in the supply of labor. It also stems from an increased demand for labor. For as employment in center II declines, output declines and thus the price for center II's product rises. This assumes that the demand for center II's product remains unchanged. Thus, the value of marginal product of labor curve ($MPP_L \cdot P_{II} = VMP_L$) shifts upward and to the right. The reverse of the foregoing effects accounts for the decline in the wage paid in center I.

point E would be located just to the right of point M. Given the then prevailing wages in the two centers (W_0 for center I and W_2 for center II) workers cease to change employment between centers. Short-run equilibrium prevails.

The long run.--In the long run, both capital and labor are free to migrate between local labor markets. Since the value of marginal product of labor is higher in center II than center I, there is an incentive for labor to migrate from local labor market I to local labor market II. On the other hand, the value of marginal product of capital is greater in center I than center II, and thus there is an incentive for capital to migrate from center II to center I. To the extent that the latter occurs, the necessity for labor migration is reduced. As these migrations occur (some combination of both or either independently), the wage rises in center I and falls in center II with corresponding shifts in each local labor market's net wage curve. This movement toward long-run equilibrium is dampened however; for as the net wage curves shift, workers, given their place of residence, tend to leave employment in center II for employment in center I; that is, the spatial point of worker indifference between the two centers moves rightward in Figure 31 as the net wage curve shifts upward in market I and downward in market II. Thus the migration of labor (and capital) between local labor markets must be large enough to swamp this countervailing movement for the re-establishment of long-run equilibrium.

The process described above ceases when: (1) the value of marginal product of labor is equal in both local labor markets; (2) the value of marginal product of capital is equal in both local labor markets, and (3) the points of tangency and intersection of equal iso-time curves

represent the boundary line delimiting the two local labor markets. When these conditions prevail, there is no incentive for change. Long-run local labor market equilibrium has been achieved. The I II' curve in Figure 30 is the locus of points generated by the tangency and intersection of equal iso-time curves. It represents the new long-run equilibrium delimitation of the two local labor markets. Point B in Figure 31 represents the establishment of one point on the I II' curve. Thus it is concluded that a disturbance of local labor market equilibrium due to a change in highway facilities automatically sets into motion forces that tend to re-establish equilibrium.

CHAPTER IX

SUMMARY

The basic system of equations for the theory of local labor market delimitation in general and the net wage function in particular is:

$$W_n = f(W, C_n) \tag{9.1}$$

$$W = \alpha(MPP_L, P_x) \tag{9.2}$$

$$C_n = \beta(C_t, TT_c) \tag{9.3}$$

$$C_t = \phi(M, TT) \tag{9.4}$$

$$TT_c = g(TT_e, H, W, C_t) \tag{9.5}$$

$$TT_e = h(L_f, L_r, L_a). \tag{9.6}$$

The symbols have the following meaning: W_n, net wage; W, wage; C_n, net costs; MPP_L, marginal physical product of labor; P_x, price of the product; C_t, travel costs; TT_c, travel time costs; M, medium of transportation; TT, travel time; TT_e, travel time that can be eliminated by alternative employment; H, hours of the normal working day; L_f, location of the employment center; L_r, location of residences; L_a, location of alternative employment centers. The following variables are regarded as given: MPP_L, P_x, M, TT, H, L_f, L_r and L_a.

In this study the form of the net wage function is represented by equation (6.6):

$$W_n = \frac{W - b(TT)}{H + TT_e} \cdot H . \tag{9.7}$$

This function indicates the relationship between the net wage ($W_n = W - C_n$, by definition) and travel time associated with those spatial locations comprising a vector, given the value of marginal product of labor. The spatial locations comprising a vector must satisfy the following condition:

$$TT_v = TT_I + TT_{II} \tag{9.8}$$

where, TT_v is a constant travel time; TT_I and TT_{II} are the respective travel times from a given spatial location to the two employment centers (designated I and II) whose local labor markets are to be delimited. Since the vector is taken as given, the vector travel time, TT_v, is known. From equation (9.8):

$$TT_I = TT_v - TT_{II}. \tag{9.9}$$

By definition:

$$TT_{e_I} = TT_I - TT_{II}, \quad TT_I > TT_{II} \tag{9.10}$$
$$= 0, \text{ otherwise;}$$

$$TT_{e_{II}} = TT_{II} - TT_I, \quad TT_{II} > TT_I \tag{9.11}$$
$$= 0, \text{ otherwise.}$$

From equations (9.9) and (9.10):

$$TT_{e_I} = TT_v - TT_{II} - TT_{II} \tag{9.12}$$
$$= TT_v - 2TT_{II}.$$

A spatial location represents one point on a curve delimiting local labor markets when it meets the following condition:

$$W_{n_I} = W_{n_{II}} \tag{9.13}$$

where W_{n_I} and $W_{n_{II}}$ are the net wages yielded by employment at center I and center II respectively for an individual residing at a given spatial location. Since the net wage takes into account travel costs and travel time, the worker residing at a spatial location meeting the condition of

(9.13) would be indifferent between employment at center I or II. Such a spatial location represents one point on the curve delimiting local labor markets. By definition, the following relationships exist for such a spatial location:

(9.14) $TT_{e_I} = 0$ and $TT_{e_{II}} = 0$, when $W_I = W_{II}$;

(9.15) $TT_{e_I} > 0$ and $TT_{e_{II}} = 0$, when $W_I > W_{II}$;

(9.16) $TT_{e_{II}} > 0$ and $TT_{e_I} = 0$, when $W_{II} > W_I$.

The process for identifying one point on a curve delimiting the local labor market of centers I and II will be set forth now. Using equation (9.7) the net wage equation for each center will be set up. It is assumed that $W_I > W_{II}$. The net wage function for center I is:

$$(9.17) \qquad W_{n_I} = \frac{W_I - b(TT_I)}{H + TT_{e_I}} \cdot H \ , \ TT_{e_I} > 0.$$

The net wage function for center II is:

$$(9.18) \qquad W_{n_{II}} = \frac{W_{II} - b(TT_{II})}{H + TT_{e_{II}}} \cdot H \ , \ TT_{e_{II}} = 0.$$

From equations (9.9), (9.12), (9.15) and (9.17) center I's net wage function also can be expressed as follows:

$$(9.19) \qquad W_{n_I} = \frac{W_I - b(TT_v - TT_{II})}{H + TT_v - 2TT_{II}} \cdot H \ .$$

From equations (9.15) and (9.18) center II's net wage function also can be expressed as follows:

$$(9.20) \qquad W_{n_{II}} = \frac{W_{II} - b(TT_{II})}{H} \cdot H \ .$$

Set equations (9.19) and (9.20) equal to each other and solve for TT_{II}.

Subtracting the results so obtained from TT_v yields TT_I. The spatial location on the given vector corresponding to the travel times so obtained meets the condition set forth in (9.13). The spatial location so identified represents one point on the curve delimiting local labor markets I and II, given the wage paid in center I and the wage paid in center II. By repeating the foregoing procedure for an infinite number of vectors, a locus of points is generated that delimits local labor markets I and II.

So long as $TT_I \neq TT_{II}$ for those spatial locations that delimit local labor markets I and II, long-run local labor market equilibrium does not prevail. The inequality in TT_I and TT_{II} indicates that the optimum allocation of labor and capital has not been achieved. Only when the optimum allocation of resources is obtained will $TT_I = TT_{II}$ for those spatial locations forming the boundary line between local labor markets I and II.

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VITA

Richard William Poole

Candidate for the Degree of

Doctor of Philosophy

Thesis: A THEORY OF LOCAL LABOR MARKET DELIMITATION

Major Field: Economics

Biographical:

Personal Data: Born in Oklahoma City, Oklahoma, December 4, 1927.

Education: Received the Bachelor of Science degree from the University of Oklahoma in June, 1951; received the Master of Business Administration degree from the University of Oklahoma in June, 1952; completed one year of part-time graduate study at the George Washington University; completed requirements for the Doctor of Philosophy degree in August, 1960.

Professional Experience: Research Analyst, Oklahoma Gas and Electric Company, 1952-1954; Manager, Scientific and Manufacturing Development Department, Oklahoma City Chamber of Commerce, 1954-1958: includes a year's leave of absence to serve as Assistant to the President, Frontiers of Science Foundation, 1956, and a year's leave of absence to serve as Manager of the Washington, D.C. office of the Honorable James E. Webb, 1957-1958.