THE SEPARATION OF WORK AND RESIDENCE:

A Case Study of Employees of Fort Garry Industrial Area No. 1, Winnipeg

by

Richard J. Powell

A thesis submitted to the Faculty of Graduate Studies at the University of Manitoba in partial fulfillment of the requirements for the degree of Master of City Planning.

Winnipeg

1977

THE SEPARATION OF WORK AND RESIDENCE: A CASE STUDY OF EMPLOYEES OF FORT GARRY INDUSTRIAL AREA NO. 1, WINNIPEG

BY

RICHARD J. POWELL

A dissertation submitted to the Faculty of Graduate Studies of the University of Manitoba in partial fulfillment of the requirements of the degree of

MASTER OF CITY PLANNING

TABLE OF CONTENTS

ILLUSTRATIONS

Figure

Map

LIST OF TABLES

Table

PREFACE

The journey to work is a fundamental aspect of human ecology. It has profound impacts on:

1) the image and structure of urbanized areas through the requirement for and location of arterial roadways and public transit rights of way which in turn affect adjacent land use;

2) the quality of life in the urban environment through the noise and air pollution generated by commuters;

3) the increasing rate of consumption of limited fossil fuel resources;

4) the expenditure of public funds for transit systems, transportation corridor improvements and maintenance;

5) the expenditure of private funds for transit fares or owning and operating private automobiles;

6) the loss of time spent on commuting which could have been devoted to other, more enjoyable or productive persuits.

In order to minimize and rationally plan for commuting, it is necessary to understand the many factors affecting the length of the worktrip or the travel time separation between homes and jobs. This thesis attempts to further that end, and it is divided into three principle areas:

1) An analysis of the factors affecting the separation of work and residence;

2) A discussion of the development of mathematical spatial interaction models which may be used to predict the separation between work and residence; and,

3) A case study of the work-residence separation of employees of an industrial area in Winnipeg.

The work outlined above could not have been completed without the support and assistance of many individuals. I would like to acknowledge my indebtedness to:

1) The Transportation Development Agency of the Canadian Government for their financial support in the form of a TDA Fellowship;

2) The managers of the firms in Fort Garry Industrial Area No. 1 who gave of their time and provided the majority of the data required for the case study;

3) The Streets and Transportation Division of the City of Winnipeg who provided 1971 travel time data;

4) Frank Saccomanno, whose thesis suggested many of the procedures employed in the case study; and finally,

5) To my wife, Sheila, for her continuing patience and assistance.

CHAPTER I

FACTORS AFFECTING THE SEPARATION OF WORK AND RESIDENCE

Introduction

For any given place of work, there is an unique frequency distribution of its employees residing at various time-distance intervals away. This work-residence separation distribution is the product of two basic factors; the distribution of the supply of suitable residential opportunities around the workplace, and the demand distribution of employee work trip travel propensities.

The residential opportunity distribution is uniquely determined by the surrounding land development pattern and transportation system. Generally, opportunities increase as the area of development around the work trip destination increases, and then they fall off as the limit of urban development is reached.

At the metropolitan level, the opportunity distribution is affected by several parameters of urban structure. For example, average opportunity spacing increases with city size, spread and land use uniformity, and it decreases with increasing population density, compactness and intermingling of land uses. A city's transportation infrastructure also affects the

nature of the opportunity distribution, especially when it is measured in terms of travel time, through the directness and speed of the commuting modes and routes it provides.

The opportunity distribution will be different for each commuter, or each relatively homogenous group of commuters with a common destination or origin, according to individual definitions and perceptions of what is a suitable opportunity, as well as the relevant characteristics of the residences and workplaces which are available. For example, what is a suitable employment opportunity will vary according to the jobseeker's occupation, experience and salary expectation. Similarly, a suitable residential opportunity will be determined by the individual's income, socio-economic status, family size, life cycle stage, tenure preference, taste for dwelling type, neighbourhood services and amenities. Opportunities may also be restricted for some individuals by virtue of racial discrimination or some form of subsidization.

The second major factor involved, the distribution of work trip travel propensities, measures the willingness and ability of commuters to expend time, money and effort in travelling to work. As a result of travel impedance, most people prefer to travel as little as possible, while a few are willing and able to travel further. Work trip travel propensity is largely dependent on psychological or subjective factors such as attitudes toward work and home, and enjoyment of travel. These factors vary considerably throughout the population and are difficult to quantify. Since work trip travel involves money costs, ability to pay or income is to a large extent a quantifiable determinant of ability to travel. Similarly, factors such as occupation, sex, education and life cycle stage which are correlated with income may be indicative of travel propensity.

Mathematical models of work-residence separation or work trip interaction normally include only the two basic factors as independent variables; that is, trip ends or trip end opportunities and travel time or, in some cases, intervening opportunities, as an inverse measure of travel propensity. The remaining factors are accounted for by adjustment variables, the estimation of empirical parameters, or the disaggregation of the model for specific geographic zones or population groups.

The objective of this chapter is to gain further insight into the variables affecting work-residence separation and the manner in which they interact. As such, it serves partially as a basis for Chapter II, which discusses the theoretical basis for several analytical spatial interaction models and the role of the variables and parameters used in developing them to reliably predict commuting patterns. It also serves as a basis for identifying those factors which indicate promising directions for effective planning policies aimed at reducing average commuting times, thereby conserving energy, time and money for individuals and society at large.

Travel Impedance and Work-Residence Separation

The spatial separation of an individual's place of work and his residence is, within the limitations imposed by the distribution of such places, a consequence of a pair of complex personal decisions. It is a fundamental postulate of this thesis, and a great deal of other re-

search, that a decision as to one's place of residence is linked to a previous decision as to place of employment--or vice versa--and is based, partially at least, on a desire to reduce or limit the spatial and temporal separation between the two locations. In the words of J. Douglas Carroll, Jr.,

> ...while many factors are involved in the selection of homes and places of work, the persistence of the desire to minimize the distance separating workplace from home acting through each individual worker may be the single element which can create pattern out of the aggregate choices of large numbers of workers. It is, of course, obvious that these choices are differentially limited for each individual worker so that only in large aggregates can patterns begin to appear.[1]

The pattern which is consistently observable is that employees of a specific workplace diminish as a proportion of resident population with increasing distance from that place of work. In other words, workers are not indifferent to the length of their work trip in the selection of their residence. This is not to say that workers as individuals or as a group select their homes and jobs in such a way that the journey to work is minimized; however, they do as a group tend more toward minimization than indifference.[2]

One of the most fundamental factors affecting the separation of work and residence is the quality of separation itself, which tends towards

---

1 J. Douglas Carroll, Jr., "Home-Work Relationships of Industrial Employees," (Ph. D. dissertation, Harvard University, 1950), p. 21, quoted in Leo F. Schnore, "The Separation of Home and Work: A Problem for Human Ecology," Social Forces 32 (December 1954): 337.

2 John R. Hamburg et al, "Linear Programming Test of Journey-to-Work Minimization," Highway Research Record 102 (1965): 67-75.

minimization. There is inherent in traversing physical distance a cost, an effort, a disutility, which is usually termed travel impedance. To the individual this may have many components; including, time lost to other activities, out-of-pocket cost, and physical effort or discomfort. All of these tend to inhibit travel and presumably result in a limitation of the total time spent travelling by each individual. Since "nearly half of all trips from home are made to work," [1] it is not unreasonable to expect that this desire to limit travel would find common expression in an attempt to reduce the separation between an individual's home and his place of work.

The actual separation between work and residence may be measured in a number of ways. The length of the worktrip itself is probably the best gauge of effective separation; although, on some occasions, the straight line distance between home and work is used as a proxy. Trip length is usually expressed in terms of over-the-road distance or trip time. In order to account for speed variation, congestion effects, and in some cases, terminal delays, time is generally the preferred measure.

In terms of the traveller's immediate perception, trip time and out-of-pocket costs are undoubtedly the most important measurable deterrents to travel. While some attempts have been made to combine time and costs

---

1 John F. Kain, "The Journey-to-Work as a Determinent of Residential Location," Papers and Proceedings of the Regional Science Association 9 (1962): 139.

into a single travel impedance measure, it has proven very difficult to place a uniform and meaningful dollar value on time. For this reason, for a given mode of travel one often assumes that out-of-pocket costs, and sometimes terminal delays, are either approximately equal for all travellers or are of secondary importance to them in comaprison with actual travelling time. Travel time, then, is widely accepted as the most convenient and meaningful measure of effective work-residence separation.

The variation in average travel time for various groups of workers or work-trip situations can, therefore, be used to draw conclusions about the many worker and urban characteristics which influence home-job separation. Alan M. Voorhees and Associates used data from a number of cities in the United States and Canada to analyse the factors affecting the length of urban worktrips.[1] They found that the average worktrip length in most cities was between ten and fifteen minutes for automobile drivers. They also synthesized a representative auto-driver worktrip travel time distribution for an average North American City. This distribution, presented in figure 1, can be shown to approximate a gamma distribution.[2]

---

1 Alan M. Voorhees and Associates, Factors and Trends in Trip Lengths, National Cooperative Highway Research Program, Report No. 48 (Washington: Highway Research Board, 1968); and Alan M. Voorhees and Associates, Factors, Trends and Guide-lines Related to Trip Length, National Cooperative Highway Research Program Report No. 89 (Washington: Highway Research Board, 1970).

2 The gamma density function takes the form: $f(t)=K\left\{t^{(\bar{t}-\delta_t^2)/\delta_t^2}\right\}\left\{e^{-(\bar{t}/\delta_t^2)t}\right\}$
where $f(t)$ = the relative frequency of trips of duration t
K = a constant
e = the base of the natural logarithm (2.71828)
$\bar{t}$ = average trip duration
δ_t = the standard deviation of trip duration.

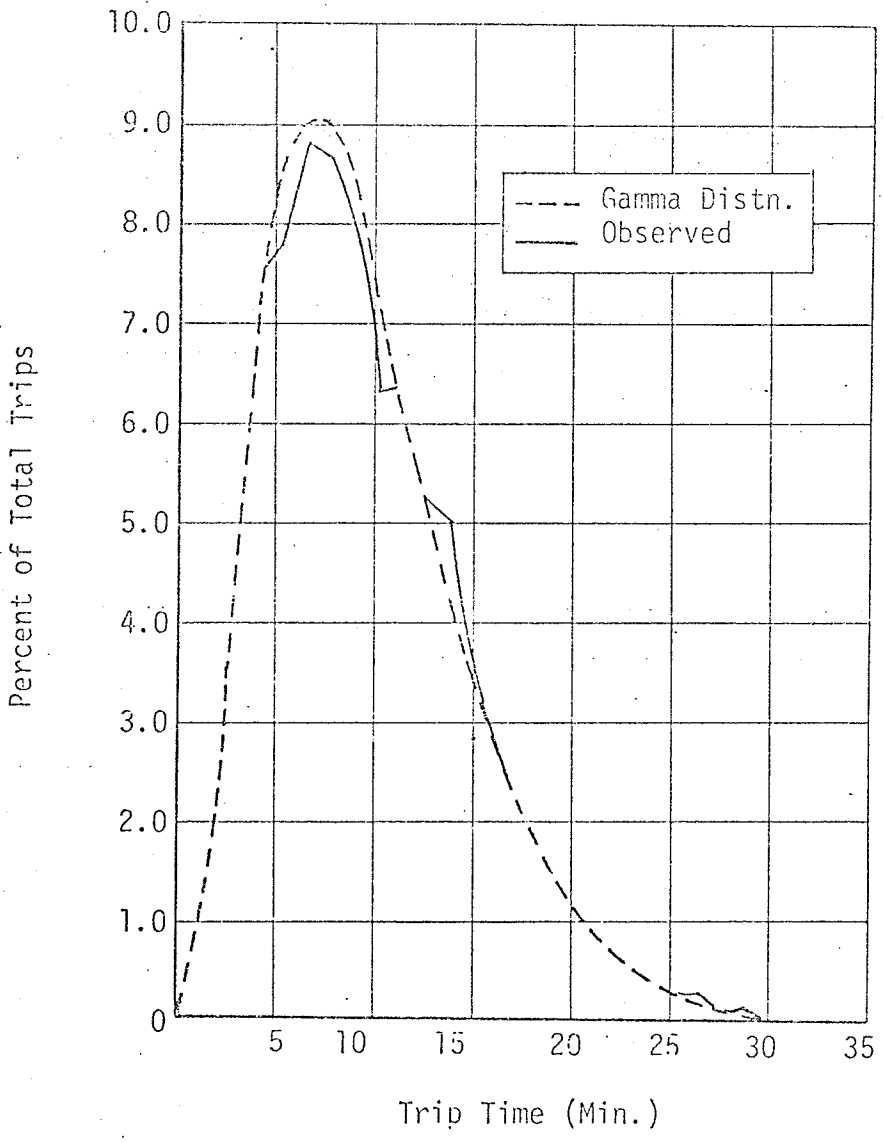

FIGURE 1: Auto-Driver Work Trip Distribution, Erie, Pa.

(Source: Voorhees and Associates, "Factors and Trends", Appendix B)

At first glance, the distribution appears to contradict the notion that there is a desire on the part of workers to reduce home-work separation, since there are very few of the shortest worktrips. The reason, of course, is that normally there are few residences in the immediate proximity of places of work. One of the most important factors affecting the separation of home and work is the distribution of residential opportunities with respect to workplaces, or vice versa.

The Work-Residence Opportunity Distribution

Historical land development patterns, traditional zoning practices, economies of scale and proximity, and many other factors have over the years produced urban landscapes composed of residential districts distinct from employment districts. Many North American cities have a central core devoted almost exclusively to commercial and office use, which is surrounded by residential development except for a few sectors dedicated to industrial use. Even where there are residences in proximity to jobs, very often the types and prices of the residences are not suited to the requirements of employees working nearby. As a result, we have downtown office workers commuting to new housing in the suburbs while industrial workers from inner-city neighbourhoods commute to suburban industrial parks.

The development pattern described above significantly limits the opportunity for a worker to find a suitable residence close to his job. It is not surprising, then, that many concerned with urban transportation problems have advocated altering current development practice to place

appropriate housing in close proximity to employment centres.[1] Edward M. Bergman has even suggested that a performance standard for residential zoning be the radius of a reasonable commuting distance from an employment centre.[2] In other words, if a proposed residential development of a certain type and affordability were located more than a given distance from a centre employing sufficient potential consumers of such housing, the necessary zoning would not be granted.

The impact of the current distribution of homes and jobs on the length of worktrips is a factor which must be given careful consideration in analysing any apparent desire to reduce work-residence separation.

Voorhees and Associates have also defined a worktrip length opportunity distribution, which is based upon the frequency distribution of the travel time separation between all potential homes and jobs in various North American Cities.[3] This distribution, shown in figure 2, appears to be approximately normal in form and is largely a function of city structure and transportation network speed.

---

1 See for example, Wilfred Owen, The Accessible City (Washington: The Brookings Institute, 1972) and Hans Blumenfeld, Canadian Planning Issues (Ottawa: Canadian Institute of Planners, 1976) p. 11.

2 Edward M. Bergman, Eliminating Exclusionary Zoning: Reconciling Workplace and Residence in Suburban Areas (Cambridge, Mass.: Ballinger Publishing Company, 1974), pp. 37-39.

3 Alan M. Voorhees et al, "Factors in Work Trip Lengths," Highway Research Record 141 (1965): 27.

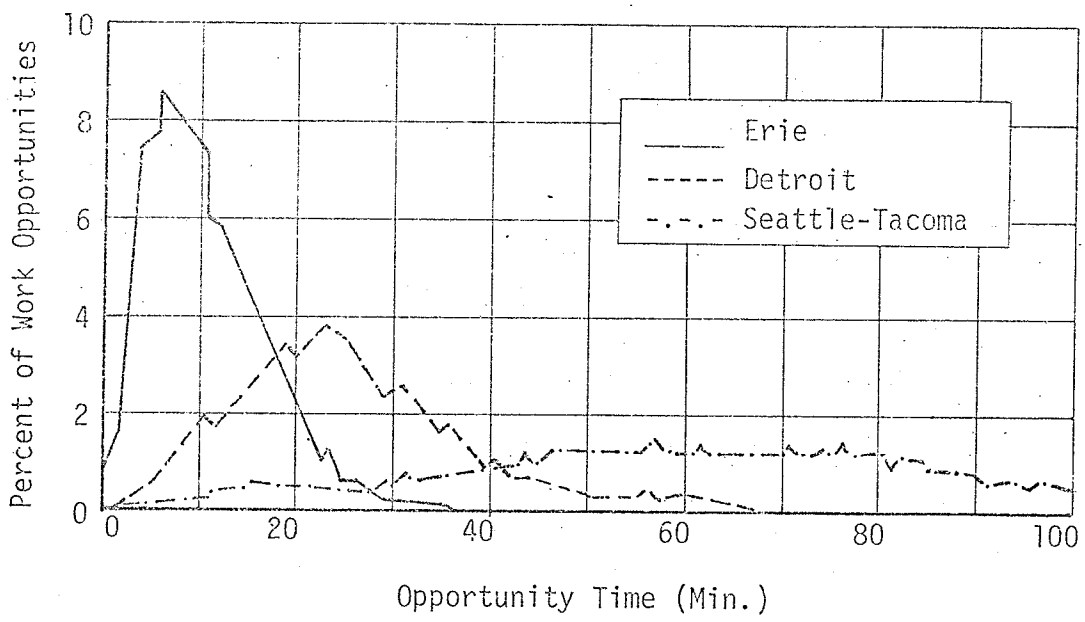

FIGURE 2: Work Trip Opportunity Distribution for Three Cities

(Source: Voorhees et al, "Factors in Work Trip Lengths," p.28)

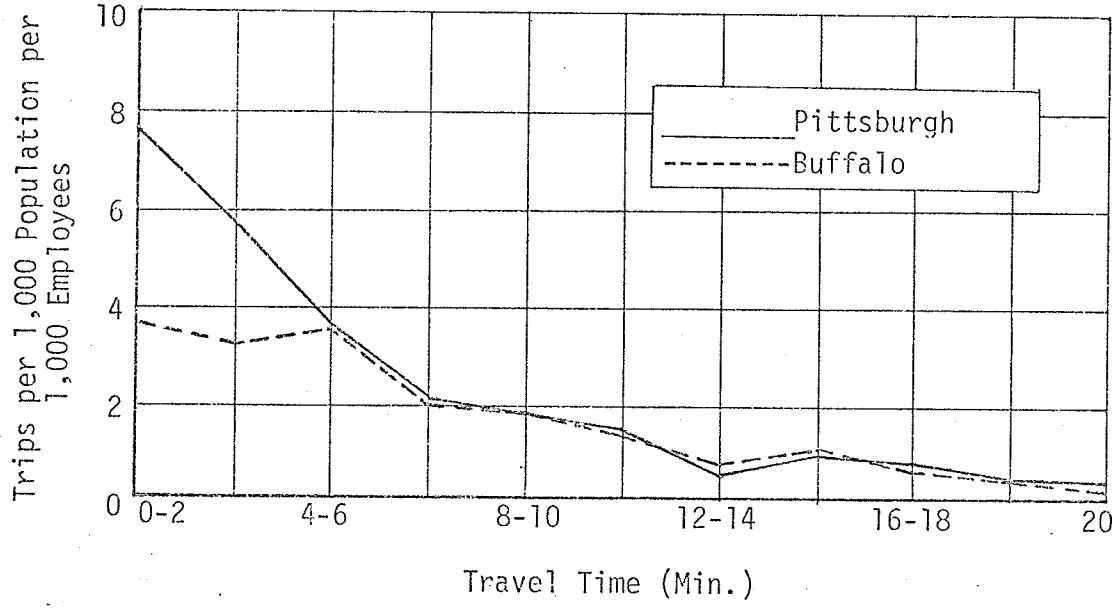

FIGURE 3: Auto Driver Work Trip Rates by Travel Time, Normalized by Plant Employment. (Source: Keefer, Airports, Shopping Centers and Industrial Plants, p.82)

When the trip length opportunity distribution, or the population distribution[1] around a particular concentration of employment, is taken into account, it has been found that the shortest feasible worktrip lengths do predominate. For instance, Louis J. Keefer found that auto driver trips per one thousand population, normalized by plant employment, for worktrips to industrial plants in Pittsburgh and Buffalo were distributed as indicated in figure 3.[2] Generally, the frequency of trips appears to exhibit an exponential decline with increasing trip length.[3]

The necessity of considering an opportunity distribution for worktrip origins can also be brought into perspective by examining two basic interpretations of the apparent tendency to limit work-residence separation. As we shall see in Chapter II, the difference between these two interpretations are manifest in the two fundamental spatial interaction or trip distribution models, currently in use. In that emphasized by

---

1 Population distribution may be used as a rough proxy for residential distribution.

2 Louis E. Keefer, Urban Travel Patterns for Airports, Shopping Centers and Industrial Plants National Cooperative Highway Research Program, Report No. 24 (Washington: Highway Research Board, 1966) p. 82.

3 The exponential distribution is given by $f(t) = \lambda e^{-\lambda t}$ where $f(t)$ is the frequency of worktrips of duration t, e is the base of the natural logarithm and λ is an empirically determined parameter. It serves as a convenient generalized mathematical representation of travel propensity phenomena as suggested by its analytical tractibility and the usual shape of observed data. It provides a widely applicable, statistically generated family of curves which allows the user to select an optimal parameter value to suit the case at hand, rather than estimating a separate model for each application.

the Gravity Model, the separation between two points is assumed to possess an inherent impedance where each additional unit of distance, time, or cost serves to incrementally reduce the porbability of a trip interchange.

Another assumption, embodied in the Opportunity Model, is that impedance will prompt an individual to travel only as far as necessary and no further. Under these circumstances, the amount of competition for suitable opportunities closer at hand will determine the ultimate distance at which satisfaction may be achieved. It is difficult to ascertain which approach best represents the actual perception and motivation of trip makers, and undoubtedly, elements of both are involved.

Impedance and the distribution of suitable trip-end opportunities are the most fundamental factors affecting the separation of work and residence; however, there are other, more empirical, factors which moderate the basic relationships already described. These other factors include observable characteristics of the urban structure, transportation system, place of work, place of residence, and worker population involved.

Urban Structure

Mean worktrip length appears to be directly proportional to the size of urban centre concerned. Voorhees found that cities in the 100,000 population range had average automobile worktrip lengths in the order of