ACCESS TO JOBS AND WILLINGNESS TO TRAVEL

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ABRIDGMENT

•DURING the past few years, a number of studies have examined differences in access to jobs from different residential areas in the city and by different modes of travel (1, 2, 3, 4, 5, 6, 7, 8, 9). Generally these studies compared travel time by car and travel time by public transit to show that the worker who had to travel by bus, on the average, traveled as much as 3 times longer door-to-door as the worker who traveled by automobile. By so doing, he had access to almost the same number of jobs as his neighbor with a car had in a city like Buffalo, New York (12). To some extent, the bus rider is excluded from a significant proportion of jobs that are not served by bus lines.

Studies that examined the performance of bus experiments to improve access to suburban jobs, in general, concluded that conventional bus service, as a means to transport inner-city workers to suburban jobs, was not a reasonable solution. The average cost per rider was too high, suburban job locations were too dispersed to be served efficiently by public transit, and the off-peak demand was very small (7, 8).

Important factors, not examined in these studies, are the worker's perceptions of prospects for stable career development in the suburban job and how perceptions of commuting by bus fit into the life style and self image of the worker. A framework for analyzing these factors is presented in another report (10). Published studies by Wachs and Schofer (9) and by Gustafson et al. (11) have examined attitudinal responses to transit characteristics but have not gone beyond to examine aggregate measures of willingness to travel.

This paper summarizes a study in which an aggregate measure of the willingness to travel to work was developed by using, as a basis, the friction factor incorporated in the gravity model for trip distribution. The willingness of automobile users and bus riders were compared for 4 different occupational groups.

DERIVATION OF A WILLINGNESS MEASURE

An ideal measure of willingness should be independent of the particular spatial distribution of jobs and should be independent of the attractiveness of particular jobs. It should be a function of travel time (door-to-door) and mode of travel only. The concept of friction factor as used in the gravity model for trip distribution is ideally suited as a basis for deriving a willingness measure.

The gravity model can be viewed as an equation for estimating the travel activity patterns of persons where trips originate in a zone i and are destined to a zone j; the number of person trips from i to j is T_{ij}. The equation is written in the following form:

$$T_{ij} = P_i \left(A_j F_{ij}\right) \Big/ \left(\sum_{j=1}^{n} A_j F_{ij}\right) \qquad (1)$$

where P_i is the total number of trips produced in zone i for a particular trip purpose, say, work or shopping trips, and A_j is the total number of trips attracted to zone j for that same purpose. The term F_{ij} is commonly called a friction factor and is defined subsequently.

The friction factor F_{ij} decreases with increasing travel time between zones i and j. For a pair of zones, i-j, F_{ij} may be interpreted as a measure of the decreases in attractiveness of a zone or of the willingness to travel there as the travel time to that zone increases. In other words, the factor F_{ij} can be interpreted as a measure of the strength of the willingness to travel as a function of travel time.

Analyses that used the following equation to represent the variation of F_{ij} with travel time are presented in another report (13):

$$F_{ij} = [\alpha\beta/\gamma(\alpha)]\ t^{\alpha-1.0}e^{-\beta t} \tag{2}$$

This equation is the so-called gamma distribution with $\gamma(\alpha)$ equal to $(\alpha - 1)$. The 2-parameter equation provides an efficient way to describe the friction factor with a shape parameter α and a scale parameter β.

CALIBRATION OF GRAVITY EQUATION

The gravity equation, Eq. 1, was programmed for calibration on the CDC 6400 computer at the State University of New York at Buffalo. Origin-destination data from a 1968 survey of work trips in the black ghetto of Buffalo were used, and the particular computer program was developed and converged within 4 iterations to obtain averaged F_{ij} values that replicated averages of the observed T_{ij} values to within 2 percent. Three hundred destination zones were used for trips from each of 7 origin zones. The averaged F_{ij} and T_{ij} values represented time averages of all F_{ij} or T_{ij} within 5- or 10-min time bands. The 10-min time bands were used for bus trips, and the 5-min bands were used for automobile trips (12).

The most important conclusions obtained from examining the F_{ij} curves were as follows: (a) The friction factor curves for bus trips were more erratic than those for automobile trips and did not follow the analytical equation as closely as did the automobile curves; (b) much of the erratic nature in the bus curves was due to the small sample size (fewer than 10 trips for a particular origin zone); and (c) with the aid of families of curves for different values of the parameters α and β, the values $\alpha = 1.2$ and $\beta = 0.08$ were selected as providing a good fit to the friction factor for automobile commuters, whereas $\alpha = 1.7$ and $\beta = 0.04$ were obtained for bus riders (4, 12).

UNITY MEASURE OF WILLINGNESS

The sampling variability was reduced by having 1 numerical measure of friction rather than several points on a curve. Therefore, the friction factor curves were reduced to 1 numerical measure by forming a ratio of average travel time to work by workers residing in a zone divided by the ideal travel time to work if there were no attenuating effect for long trips. This ratio was called the friction index.

In mathematical terms, the friction index was derived as follows. The average of travel time for observed trips from zone i is

$$\overline{t_i} = \left(\sum_{j=1}^{j=n} T_{ij} \times t_{ij}\right) \Big/ \left(\sum_{j=1}^{j=n} T_{ij}\right) \tag{3}$$

where

T_{ij} = observed sample of work trips from zone i to zone j,
t_{ij} = travel time from zone i to zone j,
$\overline{t_i}$ = average travel time of workers from zone i,
A_j = total number of workers employed in zone j, and
n = total number of work zones considered.

$$\overline{\text{Ideal } t_i} = \left(\sum_{j=1}^{j=n} A_j \times t_{ij}\right) \Big/ \left(\sum_{j=1}^{j=n} A_j\right) \tag{4}$$

$$\text{Friction index} = F_i/\text{ideal } t_i \tag{5}$$

Table 1. Comparison of friction indexes for occupational groups.

Mode	Occupational Group	Friction Indexes: Using Total A_j	Manu-facturing A_j	Nonmanu-facturing A_j
Automobile drivers and riders	Male operatives	0.837	0.816	
	Male laborers	0.822	0.802	
	Male others	0.695		0.646
	Female workers	0.453		0.423
Bus riders	Male operatives	0.662	0.646	
	Male laborers	0.743	0.725	
	Male others	0.635		0.592
	Female workers	0.587		0.548
Ratio of automobile to bus indexes	Male operatives	1.26	0.646	
	Male laborers	1.093	0.725	
	Male others	1.093		0.592
	Female workers	0.772		0.548

Table 2. Comparison of friction indexes.

Ratio of Friction Indexes[a]	Automobile Users	Bus Riders
Male operatives and male laborers	0.993	0.87
Male operatives and male others	1.175	1.019
Male laborers and male others	1.182	1.08
Male others and female workers	—	1.08

[a]Male operatives friction index based on manufacturing A_j. Male laborer, male others, and female worker friction indexes based on total A_j.

Typical values for the friction index are given in Table 1 for bus and automobile modes of travel for 4 occupational groups. The friction indexes were calculated for the job distribution A_j (all types of occupations grouped together), for a distribution of manufactoring jobs only, and for a distribution of nonmanufacturing jobs derived as the difference between the latter 2 distributions. (Information on the approximate number of manufacturing jobs in each zone was available from New York State Department of Transportation data.)

Ratios of the friction index for automobile to that for bus are given at the bottom of Table 1. Dividing the automobile value by the bus value removed (canceled out) the effects of the particular A_j distribution on the friction index, and thus it can be shown that the ratios of friction index can also be obtained from a ratio of average travel time by car to that by bus for workers in a particular occupation (12). The ratios indicated that male operatives with a ratio of 1.26 were less inhibited by the friction of space when traveling by car than when traveling by bus. Male laborers and other male workers did not have so different a response between car and bus users because, for these latter 2 groups, the ratios were close to unity, 1.10 and 1.093 respectively.

Let us assume, for lack of more detailed data, that the job distributions of bus riding and automobile riding operatives were best represented by the manufacturing A_j distribution and that male laborers and other males using both modes of travel were best represented by the total A_j distribution. Then the friction indexes are useful for comparing the willingness to travel for these occupational groups.

Ratios of these friction indexes are given in Table 2 and indicate that male operatives were less willing to overcome the friction of space than male laborers, for the ratios of friction indexes for these 2 occupations were less than 1.0. This conclusion was valid, however, only if the A_j distributions used, as given in Table 2, were appropriate. Unfortunately no better data were available.

Similarly, male operatives were more willing to travel than other males, automobile users more so than the bus riders, and male laborers more so than other males.

CONCLUSION

This brief summary shows that it is possible to develop useful measures of willingness to travel as a measure of travel time only if one has specific data on the spatial distribution of jobs for the particular occupational groups under consideration. These indexes effectively separate the attractiveness of particular jobs from the effect of travel time to the job.

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