USE OF SOCIOECONOMIC INDICATORS IN TRIP ATTRACTION OF LARGE WORK CENTERS

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•IN trip-generation analysis, transportation planning has been concerned with the establishment of a functional relation between trip-end volumes and the land use and socioeconomic characteristics of the units from which they originate or to which they are destined (1). Different land use and socioeconomic characteristics, or indicators, have been used in different studies, and in some cases the models obtained were unreliable because of the interdependence of these characteristics (2). On the other hand, trip-generation analysis has been determining the functional relations based on relatively large geographic units (census tracts or traffic zones). These large geographic units led to unreliable results in small-area studies such as a central business district transportation study (3, 4, 5).

This paper attempts to analyze quantitatively the interrelations among different land use, travel, and socioeconomic indicators and to generate a trip-attraction model for large work centers instead of traffic zones.

METHOD OF STUDY

Because of the absence of socioeconomic and travel indicators by work centers, it was necessary to undertake a survey for the purpose of this study. Twenty work centers, having a large number of employees, were selected from the Atlanta metropolitan area. These employees numbering about 25,000 were surveyed by mail during the winter of 1970. The following information was obtained: age, number of children, occupation or profession, education level, number of years at work, home value or rent, lot size, distance from home to work, travel time and distance, personal and family incomes, and car ownership. Similarly, the following was obtained from the employers: number of trip attractions, floor areas, distance from the central business district, and the assessed value of the work centers.

Before employee and employer variables were coded for statistical analysis, it was imperative to quantify all variables in a scalable manner (6). All collected variables were quantified and coded easily with the exception of occupation or profession and education. Education was quantified by using the number of years the person spent acquiring an education. Occupation or profession was quantified by using the North-Hatt occupational scaling method (7).

The method of analysis used in this investigation was predicated by the nature of the data collected and the objectives of the study. The collected data were statistical in nature and are all random variables. This randomness associated with more than 1 variable, plus the interdependency of the variates brought the problem into the realm of multivariate statistics (8).

Two subfields of multivariate statistical analysis were chosen to achieve the objectives of this investigation: factor analysis and component analysis (9). Factor analysis was used to group the observed variables together in ways that permit one to synthesize new entities called factors, or indicators, and to determine the degree of association among these variables. These factors are independent one from the other; i.e., they are orthogonal vectors and they occur in descending order as far as variances are concerned. That is to say, the first factor explains the largest portion of the total variance of the original variables.

Component analysis was used to generate a multivariate statistical model relating the number of trips attracted to work centers to the socioeconomic and travel factors

determined from the factor analysis. This analysis starts by determining statistically independent groupings called components. These components are tested for their significance by using multivariate statistical tests, and only the significant components were used in the regression operation to generate the multivariate model.

IDENTIFICATION OF EMPLOYEE AND EMPLOYER INDICATORS

This analysis consisted of identifying the socioeconomic and travel indicators pertinent to the employee and to the employer.

Identification of Employee Indicators

The employee socioeconomic and travel indicators were identified after the employee-connected variables were factor-analyzed. This analysis was performed in 2 steps. The first step analyzed the interrelation among the employee-related variables of all the work centers. This analysis indicated that the 13 variables collapsed into the following 6 factors: 2 socioeconomic indicators having the variables occupation, education, personal and family incomes, age, and years at work strongly interrelated among themselves; 1 travel indicator having the variables travel time and distance strongly associated with it; 1 home indicator having the variables home value, rent, and lot size strongly associated with it; 1 car-ownership indicator having the number of cars in a family related to it; and 1 family size indicator having the number of children related to it (10). The second step was to choose 1 variable from each factor given above, to determine the averages of these variables by work center, and then to factor-analyze them. The variables chosen were number of children, occupation level, home value, number of cars, family income, and distance of travel. Their choice was made depending on their degree of association with their corresponding factors. The factor analysis of the averages of the 6 employee variables of the 20 work centers surveyed showed that these variables were grouped into 4 independent factors. The first factor indicates that the averages of the variables occupation, home value, and family income were strong interrelated under a single factor. The second factor is a single variable factor having the average number of children strongly associated with it. Similarly, the third factor is also a 1-variable factor having the average distance of travel strongly related to it. Conversely, the fourth factor indicates that the averages of the 2 variables, number of cars and family income, are highly interrelated under it. These 4 independent factors show that these employee average variables could be represented by the 4 factors, in other words, by choosing 1 strongly associated variable from each factor. The chosen average variables were number of children, occupation, number of cars, and distance of travel.

Identification of Employer Indicators

The employer indicators were identified by using factor analysis on the 4 collected variables: floor space, distance from the Atlanta central business district, assessed value of work center, and number of work trip attractions. This analysis grouped these variables into 3 independent factors. The first indicates that the number of work trip attractions variable is strongly associated with the floor space variable. The second factor is a single-variable factor having the distance from the central business district variable. Conversely, the third factor indicates that the 2 variables, number of work trip attractions and the assessed value, are interrelated and are strongly associated with this factor.

Because the objective is to generate a relation of the number of work trip attractions variables to the significantly related employer and employee variables, it is imperative to retain the 2 variables, floor space and assessed value, and to reject the distance from central business district variable from later consideration.

RELATIONS BETWEEN EMPLOYEE AND EMPLOYER INDICATORS

When the 2 sets of indicators and the significant variables of the employer and employee had been determined, a factor analysis was performed to determine the interrelations between these 2 sets. The 7 variables analyzed were number of children, occupation level, number of cars in family, distance of travel, floor space, assessed value, and number of work trip attractions. This analysis resulted in the collapse of the 7 variables into 5 independent factors. The first factor indicates that the variables floor space, assessed value, and number of work trip attractions are strongly interrelated under this factor. The second factor shows that the variables occupation, assessed value, and, to a lesser extent, work trip attractions are associated under a single independent factor. The third factor is a single-variable factor and has the number of children variable strongly associated with it. Conversely, the fourth factor indicates that the variables distance of travel, and, to a lesser extent, the number of work trip attractions are strongly associated with it. The fifth factor is a single-variable factor and has the number of cars associated with it. Therefore, the number of work trip attractions variable appears to be associated with factors 1, 2, and 4. So, choosing 1 significant variable from each of these independent factors will determine the independent variables to be used in the component regression model relating the number of work trips to the employee and employer characteristics. The independent variables chosen to relate to the number of work trip attractions variable are floor space, distance of travel, and occupation level.

TRIP ATTRACTIONS MODEL

The work trip attraction relation with the significant employee and employer variables was determined by using component analysis multivariate statistics. This component analysis starts by a principal component analysis on the independent variables floor space, distance of travel, and occupation. This principal component analysis resulted in the grouping of these variables into 3 components. The first component is strongly expressed by the variables occupation and distance of travel, and the second one is expressed by the floor space variable. Similarly, the third component is expressed by the variables occupation and distance of travel.

This analysis indicates that the variance explained by the first component contains the largest amount of variance and the variance explained by the third one contains the least amount. The significance of the amount of variance explained by these components is determined by using the Bartlett test of significance on each residual. This test indicates that, when the third component is alone as a residual, the test is not significant at 0.1 percent level. Conversely, when the first 2 components are tested at the same level, the test is significant.

Having determined the significant components, the component analysis proceeds by using regression analysis on these orthogonal components. This component regression analysis generates the following multivariate statistical model:

$$y = -240.37\, x_1 + 163.12\, x_2 + 2.10\, x_3 - 515.48$$

where

x_1 = average occupation level,
x_2 = average distance of travel between home and place of work,
x_3 = floor space, and
y = number of trips attracted to work centers.

The model can be expressed in its standardized coefficients form as

$$y = -0.142\, x_1 + 0.338\, x_2 + 0.530\, x_3$$

where the terms are defined as before. These standardized coefficients correspond to

the variables expressed with 0 means and unit variances. These coefficients show that the variable floor space contributes the most to the model and the variable occupation level contributes the least to the model.

The F-ratio test of significance performed on this model indicates that the model is significant at the 0.001 percent level. Conversely, its coefficient of multiple determination is 0.378 implying that only about 38 percent of the variation in the number of trip attractions to the work centers is explained by the model. Also, the efficiency of the model is about 14 percent, which is relatively low for predictive uses. However, it is worth noting that the structure of this model expresses a rational relation among the variables involved. The model confirms previous findings on the strong relation between the number of work trip attractions and the floor space variables (3). The model also shows that the variables average occupation level and average distance of travel affect the number of work trip attractions to the work centers. The model implies that the work centers that have a great number of work trip attractions are the ones that employ a large number of blue-collar workers. Conversely, it suggests that the large work centers tend to attract workers from a great distance from the center in order to satisfy their large demand of skills.

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