Concept of Transportation Need Revisited

K. C. KOUTSOPOULOS

A new approach in considering the concept of transportation need is suggested based on the notion that need can be determined by considering the inverse of one's ability to adjust, for a given trip purpose, aspects of this trip in response to mobility constraints. By using this criterion, two indices of need (effectiveness and efficiency) can be constructed. The application of this approach to data on the handicapped in four areas (two urban and two rural) in Iowa indicates that that the needs of the handicapped are equally met in all four areas; however, the rural systems are less efficient than the urban ones in meeting that challenge. These results are in contrast to the results of the traditional approach (existing demand met), which show great spatial discrepancies between urban and rural areas.

The subject of travel and access for the transportation disadvantaged is based on the assumption that this group actually is in need. As a result, the transportation literature is full of studies that have decried, discussed, and described their needs and that argue that the handicapped should be provided with more transportation than they now use (1). None of these studies, however, has produced concrete measures of transportation needs nor has anything of substance been written on precisely how much transportation is needed. That is, important questions related to this problem have yet to be answered. For example, how much transportation does a person need? If someone needs more transportation than he or she now uses, should his or her unsatisfied needs be supplied in full? Therefore, the concept of need (as distinct from that of travel demand) has yet to be defined and made operational. Moreover, the approaches now in use to determine transportation needs (namely, the normative, the comparative, and the perceived-need approaches) have serious conceptual and operational, as well as logical, deficiencies (2,3), which suggests that a new approach to the concept of transportation need is necessary.

NEW APPROACH TO THE CONCEPT OF NEED

A new approach to the concept of need requires reexamining what constitutes need. To say that a person needs something or needs to do something is to say that that object or that act is necessary for that person. Need indicates a relationship, namely, that of a certain kind of necessity, between an object or an act (which is said to be what is needed) and a situation that consists of a set of circumstances (constraints) and an end state (4). Logically, then, the concept of need evolves around three separate yet interrelated dimensions--those of the end state, the act or the object needed, and the constraints.

End State

The end state is what is needed to obtain an object or to do something. The necessity expressed is therefore a prospective necessity, i.e., a necessity for something. The concept of need is inseparable from a reason or reasons. There has to be a purpose for needing something. Thus the understanding of travel as a derived demand can establish a basis for determining transportation needs, not only because travel-related activities are inherently imbedded in the notion of traveling, but mainly because they represent the reason or reasons why travel is needed (the end state) (5,6).

Trips to different travel-related activities assume different roles in the consumer's goal of getting satisfaction or fulfilling needs. Therefore, it is suggested that three major classes of travel-related activities can be defined based on the different ways in which they can satisfy the needs of someone living in a modern society (7): (a) subsistence activities that are necessary to generate income for the household (mainly work and business trips); (b) maintenance activities that are related to the purchase and consumption of goods and services (shopping and personal trips); and (c) leisure activities, or voluntary activities that take place during the remainder of the time not devoted to the first two activity classes (recreational and social trips).

Act or Object Needed

Given that need may vary according to the many aspects of the act needed (and conversely for the same aspect of the act needed), need may vary with respect to different end states and need can be qualified with regard to the act (or object) by which it is related to the end state; thus a two-dimensional matrix is created between end states and aspects of the act needed.

There are three important aspects of travel: (a) the spatial attributes, related to the spatial extent of the trip (range in terms of miles or minutes is the best example of such an attribute); (b) the temporal attributes, concerned with the rate of repetition of a given activity and the time that the various types of trips were taken; and (c) the linkage, which reflects the efficiency and flexibility of travel arrangement and includes multipurpose, multimodal, and multiperson trips (7).

Constraints

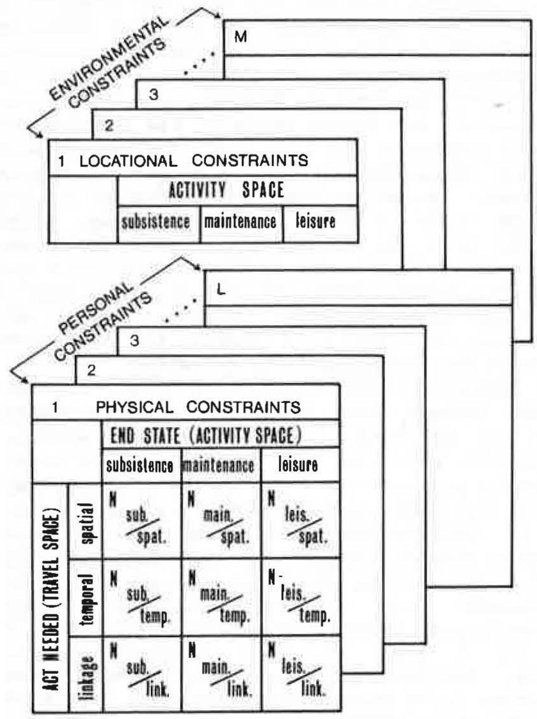
To say that a person does something because of necessity suggests a constraint. Need can therefore be further qualified with respect to the constraints related to the act needed and consequently to the end state.

The literature on transportation abounds with descriptions of factors that adversely influence (or constrain) travel. Based on a classification scheme presented by Koutsopoulos and Schmidt (8), we can divide that multitude of constraints into two groups: (a) environmental constraints imposed on a person by the physical and social environment, which could include locational constraints that result from the spatial distribution of various travel-related activities in relation to home location as well as planning and administrative shortcomings that impede travel, and (b) personal constraints, which result from a person's condition (physical or mental disabilities) as well as socioeconomic restrictions that adversely influence a person's ability to make a trip. By defining the travel constraints, the framework for determining transportation needs is now completed. Figure 1 schematically presents the three-dimensional matrix that focuses on basic factors that delineate transportation needs.

Adjustment

The conceptual framework just presented basically

Figure 1. Matrices of need.



holds that individuals in any area live in physical and social environments over which they can exert little control. These environments, however, are often changing due to exogenous complex-aggregate-level forces, which create what have been termed environmental constraints. In addition, during the course of the life cycle, as individuals grow older, get married, and have children or as their employment status or income changes, the personal constraints under which they operate also change. In the process, travel needs change or adjust to better match the new circumstances. Both environmental and individual changes invariably result in imbalances between existing ways of trip making and the ways that are necessary in order to compensate for the imposed constraints, which reflects the existence of transportation needs. Therefore, in order to determine transportation needs, it is necessary to examine how the act of traveling adjusts to modify trip-making imbalances (9).

The forms that the adjustments of the act of traveling can take include (a) spatial adjustments, which may include taking shorter trips as well as taking trips to activity nodes in different locations; (b) temporal adjustments, which may involve taking fewer trips or taking the trips at different times; and (c) linkage adjustments, which may involve combining trips for different purposes, carpooling, changing the number and type of vehicles used (also changing mode), and changing the destination or route.

Common sense dictates that a hierarchy and differences exist in these forms of adjustment. Therefore, in order to assess and quantify the various transportation needs, a criterion is required and a mechanism that can be made operational through the use of existing or obtainable data. The following criterion is suggested: Need can (and should) be determined by considering the inverse of someone's ability to adjust, for a given trip-related activity, aspects of his or her travel space in response to mobility constraints.

If one's ability to adjust the linkage aspects of his or her travel space (the act needed), which are characterized by a multitude of easily substitutable alternatives, is greater than, say, one's ability to adjust the spatial aspects (it is relatively difficult to find substitute nodes of the activity space at a shorter distance), then one's needs are far greater from a spatial point of view than they are from the point of view of the linkage characteristics. In a similar manner, if one's ability to adjust the aspects of travel space is greater for leisure activities, which are associated with highly price-elastic trips, than, say, to adjust for maintenance activities, which are characterized by price-inelastic trips, then transportation needs in terms of trips to subsistence activities are far greater than for trips to leisure activities. As a result, for a given mobility constraint, there exist at least nine groups of transportation needs, differentiated in terms of trip-related activities and travel-space aspects.

INDICES OF TRANSPORTATION NEEDS

The scheme proposed to identify, determine, and consequently differentiate transportation needs is shown in Figure 2, which is basically an enlargement of every individual square from the matrix of needs (Figure 1). For a given mobility constraint and for a specific activity and trip characteristic, this scheme classifies a group of persons as to their ability to adjust the specific aspect of their travel space and the availability of public transportation as a viable adjustment alternative. In terms of their ability to adjust, the group is subdivided into persons for whom the public transportation system is available and can provide a viable alternative in the adjustment process and those for whom the system is not available or cannot be a viable adjustment alternative. As a result, A and B in Figure 2 represent persons who in response to a constraint cannot adjust without the help of public transportation. These are the persons who have a public transportation need. Conversely, A and C represent persons for whom the system is a viable adjustment alternative. These are the persons for whose needs society provides transportation.

Based on this framework, two indices can be constructed. Need effectiveness is the proportion of persons who have a transportation need (cannot adjust on their own) and who are provided with a viable adjustment alternative (or alternatives) by public transportation: This is expressed as $T = A/(A + B)$. Need efficiency is the proportion of persons who do not have a transportation need (can adjust by using other means than public transportation) and who are not provided with a public transportation alternative or alternatives; this is expressed as $M = D/(C + D)$. Conceptually, these indices are identical to the sensitivity and specificity measures applied to medical tests (10). Therefore, in the same way that effectiveness and efficiency of various medical tests, for a given condition, are compared in terms of their relative sensitivity and specificity values, the need indices can be indicative of the effectiveness and efficiency, for a given mobility constraint, of a public transportation system or systems (in providing for the needs of a group of the transportation disadvantaged).

The important concept in this scheme is that an increase in the proportion of persons who have a

Figure 2. Criteria for identifying needs.

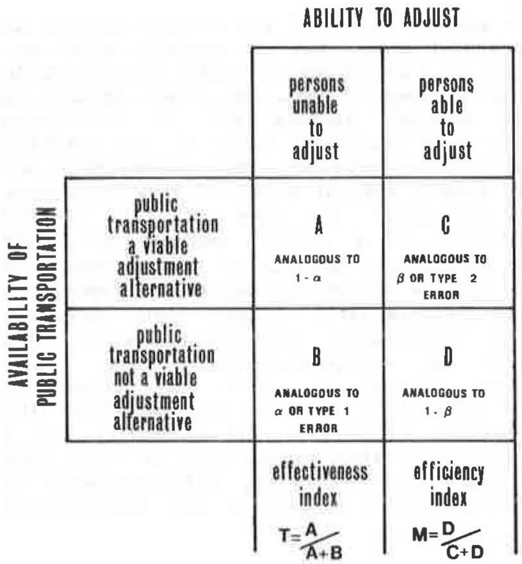


Table 1. Empirical results.

Area	Need Indices Effectiveness (%)	Efficiency (%)	Demand Met (%)
Cedar Rapids	68.3	10.3	73.5
Ottumwa	58.1	10.0	71.5
Boone County	60.0	7.1	45.9
Area XV	56.3	4.5	42.3

transportation need and for whom the public transportation system is a viable alternative will result in a decrease in the proportion of persons who do not have a transportation need and are not provided with one (or more) viable public transportation alternative. Raising the need-effectiveness index requires lowering the need-efficiency index. The ramifications of this concept for transportation planning and policy decision making are paramount in that equity considerations advocate increases in the need-effectiveness indices, whereas concerns for fiscal austerity support increases in the need-efficiency index (11).

The need-effectiveness index can and should be used for comparing different public transportation systems, for federal monitoring and subsidizing, and for evaluating the transportation services offered to various transportation-disadvantaged groups within a specific service area. The need-efficiency index may be used to compare various transportation systems within the same community or across communities and over time to measure change. The need-efficiency index can also function as a performance criterion for federal monitoring and subsidizing and for evaluating the transportation services offered to various transportation-disadvantaged groups. The same index can be used in a transit system to compare the efficiency of subregions of a service area within the system. Thus, the need-effectiveness and need-efficiency indices provide an empirical basis for program evaluation of transportation needs.

EMPIRICAL RESULTS

From June 1, 1977, through May 31, 1978, staff members from the University of Iowa's Institute of Urban and Regional Research and the Iowa Department of Transportation participated in a joint research project concerned with the transportation situation for handicapped persons in Iowa. Basically, a two-part survey was used to determine the incidence, characteristics, and travel needs of the handicapped (12). With regard to the last task, the traditional approach of comparing existing demand with supply was followed. Based on the data collected on the four target areas of Cedar Rapids, Ottumwa, Boone County, and Area XV, it was found that the urban systems of Cedar Rapids and Ottumwa supply 73.4 and 71.5 percent, respectively, of the existing demand; in the rural areas of Boone County and Area XV, however, only 45.9 and 42.3 percent of the demand for trips by the handicapped are satisfied.

These figures, which indicate a great spatial discrepancy between urban and rural areas, although they are in agreement with conventional wisdom, become suspect when the data are reexamined under the framework proposed earlier. By using these same data, the two need indices were calculated (for reasons of comparability, all trip purposes and travel-space characteristics were condensed into one category). The results (Table 1) indicate that all four systems are equally effective (their need-effectiveness index ranges from a low of 56.3 percent to a high of 68.3 percent). Their efficiency, however, differs widely (the Cedar Rapids system is 50 percent more efficient that that of Area XV), which suggests that, although the needs of the handicapped are equally met in all four areas, the rural systems (as might be expected) are less efficient than the urban ones in meeting that challenge. Therefore, traditional approaches to determining transportation needs are inadequate in explaining and pinpointing the areas of concern. As a result, before we embark into service changes and improvements to meet such transportation needs, we should be extremely cautious. The fact remains that adding equipment or routes, especially to systems that are reasonably effective and that might marginally increase their effectiveness, would inevitably result in large decreases in their efficiency, a trade-off that might not be desirable given the present economic environment.

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Near-Side or Far-Side Bus Stops: A Transit Point of View

NADIA S. A. GHONEIM AND S. C. WIRASINGHE

The optimum location of a bus stop near an intersection is defined as that which minimizes the sum of the cost of time to passengers and the operating cost of buses. Two cases, controlled and signalized intersections, are presented in this paper. A theoretical approach is adopted. A near-side and a far-side bus stop are assumed in the vicinity of the intersection under consideration. The relevant costs are calculated and compared. The location that minimizes these costs is chosen. The optimum location is shown to be dependent on the demand for boarding and alighting from the bus at the near side or the far side and on the expected delay to the bus. Some simple rules are suggested. The method is illustrated by a numerical example to show the validity and practicality of the theory developed.

In the vicinity of an intersection, a bus stop may be located at the near side or at the far side. The two sides are defined by the Highway Capacity Manual (1) as follows:

> Near-side curb stops--located at the curb on the intersection approach in advance of the intersection proper.
> Far-side curb stops--located at the curb immediately beyond the intersection proper on the straight-through exit from the approach under consideration.

The Institute of Traffic Engineers (2) has issued guidelines and recommendations for locating stops. Terry and Thomas (3) conducted a field study on a portion of a major arterial street. Their analysis indicated that far-side stops tend to be more favorable in terms of reducing queuing, providing additional maneuvering space for vehicles, and avoiding delay to right-turning vehicles. However, Feder (4) recommended the near-side stop, since it allows the bus to achieve a shorter travel time over its route. For the case in which more vehicles turn right than left at the intersection, the far-side location was recommended. Bodmer and Reiner (5) summarized the advantages and disadvantages of both locations.

The choice depends on the different factors that have been discussed in the literature. However, in all the studies carried out, no attention was given to the effect of the location on the cost of travel time to passengers and on the operating cost of the bus system. In general, the near-side, far-side studies (3-4) have considered only choosing one of the two alternatives for the complete series of intersections along a specific route; intersections have not been considered separately. These studies are either simulations or field studies. No theoretical work has been carried out as far as we can ascertain.

The objective of this paper is to investigate the optimal location of bus stops in the vicinity of some of the most-common intersection configurations. The optimum location is defined as that which minimizes the sum of the cost of travel time to passengers and the cost of operating the buses. Other factors, not included in this study, are delay to traffic, effect on right-turning vehicles, parking conditions, effect on the capacity of the intersection, and safety, which is also a primary concern.

The procedure followed in the analysis is as follows. At each intersection, a near-side location and far-side location are assumed. The related costs are calculated and compared, and the location that minimizes these costs is chosen. General rules are given when it is possible.

Other intersection configurations not discussed here can be analyzed in a similar manner (6). The general conclusion drawn from this analysis (which represents the transit point of view) and from other studies related to the near-side, far-side problem should provide a useful guide to transit planners and traffic engineers.

CONTROLLED INTERSECTIONS

Consider a four-leg intersection at which one of the streets (i.e., two opposite approaches) is controlled by stop signs (Figure 1). Buses operate on one or both approaches of the controlled street. The following analysis deals with either of the two approaches.

First, consider a near-side bus stop. It is assumed that the near-side bus stop is close enough to the stop sign so that the bus does not have to stop twice. Thus, if the bus stop was located on the near side, a bus would decelerate from its cruising speed to a stop in time t_B, load and unload passengers in time t_S, wait time t_G for a suitable gap to occur in the uncontrolled street, and then accelerate to its cruising speed in time t_A. The variables t_S and t_G are random