PREDICTING THE TYPE AND VOLUME OF PURPOSEFUL BICYCLE TRIPS

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If an adequate system of bicycle facilities is to be built, who should it accommodate? What types of trips will it be used for? This paper assumes that (a) a comprehensive system of bicycle facilities will exist in the Minneapolis-St. Paul area and (b) the maximum distance of a bicycle trip is 2 miles (3.2 km). By using these assumptions, this paper determines the percentage of trip makers by trip type who could make their trips by bicycle. The factors affecting bicycle use are discussed. Because trips whose schedule is flexible have a greater probability of being made by bicycle, bicycle systems should not be designed to accommodate trips whose schedule is rigid, such as work and school trips.

•AS IS the case with all public investments, the agencies appropriating funds for bicycle facilities want to receive the greatest benefit from the dollars spent. Some procedure is needed that will assure government officials that the type and location of bicycle facilities will exhibit a reasonable return on the investment. This return may be measured by factors such as increased safety of the bicyclist and volume of usage. This paper determines which trips are most likely to be made by the bicycle if facilities are provided and estimates the volume of those trips.

Two assumptions were necessary to produce meaningful results based on the limited factual data currently available on bicycle use. The first assumption is that a comprehensive system of bicycle facilities will exist in the Minneapolis-St. Paul study area. (This area was chosen because recent travel data were readily available.) The number of bicycle trips being made today is not a valid indication of the number of trips that can be expected. Bicycle facilities generate trips just as roads generate trips. The existing facilities in the study area are limited in number, have little continuity, and are designed and located for recreational use. The present number of purposeful bicycle trips is, therefore, far below what is possible. A comprehensive system of bicycling facilities is necessary if a substantial number of trips are to be generated. Without a continuous system connecting origins and destinations, the utility of the bicycle is severely limited. Competing with the automobile for street space is the greatest cause of bicycle accidents. Fear plus the foul air and noise makes bicycling in busy streets far from pleasant.

The definition of an adequate system is open to debate. The spacing of paths and the type of facilities are two important factors. For this analysis a grid system of routes spaced no more than ½ mile (0.8 km) apart was assumed within the beltway that encircles the St. Paul-Minneapolis area. In the remainder of the metropolitan area, a grid spacing of 1 mile (1.6 km) was assumed. No specific types of facilities were contemplated other than paths that are relatively safe. Because its safety is debatable, the signed bike route would only be used to provide access to the system of bicycle facilities.

The second assumption was that a maximum distance for a bicycle trip is 2 miles (3.2 km). A report based on bicycle use in England found that most purposeful trip makers do not travel more than 2 miles on a regular basis. Closely corresponding to this is the fact that in Rotterdam, where 43 percent of all trips are made on bicycles, the average trip time is 10 min. Based on an average bicycle speed of 12 mph (19 km/h), 10 min equals a 2-mile trip. This is an arbitrary figure, for in both England and the Netherlands, the 10-min or 2-mile measure is an average. Arguments might be presented that this distance is too short; nevertheless, because the existing data are from countries having high bicycle use, this figure will be used as the upper bound of purposeful bicycle trips.

FACTORS AFFECTING BICYCLE USE

Obviously certain trip characteristics influence which mode a trip maker will use. Table 1 gives typical conditions that increase or decrease the probability that a particular purposeful trip will be made by bicycle. This list is limited to the most important factors influencing use. The evaluation of the effect of each factor is subjective, and the assigned evaluations can be disputed. The purpose of the analysis was to determine those trips most likely to be made by the bicycle. Therefore, no one item would determine whether a trip would be made by bicycle.

The factors used to evaluate the possibility of bicycle travel were the typical conditions that existed in the study area and in most U. S. urban areas. The level of street congestion, for example, was evaluated for the various trip purposes. For the work trip a high degree of street congestion due to peak-hour movement and the concentration of trip ends was assumed to exist. This tends to encourage bicycle use inasmuch as both automobile and transit service are slowed during this period. The personal business trip, which in many instances can be accomplished at a local shopping center or other neighborhood facility in off-peak periods, was assumed to function at a free flow level of service; thus, congestion would discourage bicycle use.

The evaluation is largely self-explanatory. Two items that deserve further explanation are trip length and flexibility. The assumption is that only those trips of 2 miles (3.2 km) or less were considered possible by a bicycle. Data collected in a travel behavior inventory for the study area provided trip time in 6-min intervals, which was used as an indicator of trip length. The trip times are all for home-based vehicular trips. Because the automobile was used for more than 90 percent of all trips, the speed of the automobile was used as the measure of distance. The automobile speed was assumed to be 20 mph (32 km/h) (a high speed for door-to-door automobile use); thus, a 6-min trip would be the equivalent of 2 miles in distance. Therefore, only those trips 0 to 6 min in duration were eligible for bicycle use based on the second assumption.

Table 2 gives the cumulative percentage of trips made in Minneapolis and St. Paul during a 24-hour period in 1970 by trip purpose and trip time. Obviously, there are substantial differences in trip lengths for various trip purposes. More than 48 percent of shopping trips are made in 6 min or less, and less than 20 percent of work trips fall in this category. Because distance is an important factor in bicycle use, it should be given considerable thought when purposeful bicycle trips are provided for.

If the automobile speed is set lower, for example, 10 mph (16 km/h) for door-to-door trips, which is more likely than 20 mph, the bicycle can be used for all trips of 12 min or less. This greatly increases the percentage of trips possible by bicycle.

The other factor deserving special attention is the degree of flexibility in scheduling of a particular trip. The trips that are most likely to be made by bicycle are those whose schedule is flexible from hour to hour and day to day. The more flexible the schedule is, the greater the probability is that the trip can or will be made by bicycle. Weather is always cited as one of the greatest deterrents to bicycle use. Rain, snow, or wind along with high or low temperatures can most assuredly discourage a trip maker from using a bicycle. If a trip cannot be delayed for even a few minutes, the traveler may choose another mode over the bicycle to avoid the inclement weather. But, if the trip can be delayed an hour to let a shower pass or a day until the temperature becomes more comfortable, the probability that the trip will be made by bicycle increases. Thus, those trips made on a rigid schedule such as work and school discourage the use of the bicycle. Trips that can be made at the convenience of the trip maker (personal business, shopping) encourage bicycle use.

Table 1. Effect of selected factors on the probability of bicycle use by trip purpose.

Factors	Work	Shopping	School: Grade	School: College	Personal Business	Recreation[a]: Outdoor	Recreation[a]: Indoor
Flexibility of schedule	Considerable discouragement	Moderate encouragement	Considerable discouragement	Considerable discouragement	Considerable encouragement	Moderate encouragement	Moderate discouragement
Average trip length	Considerable discouragement	Considerable encouragement	Considerable encouragement	Moderate discouragement	Considerable encouragement	Moderate encouragement	Moderate encouragement
Age of trip maker	Limited effect	Limited effect	Considerable encouragement	Considerable encouragement	Moderate discouragement	Moderate encouragement	Limited effect
Availability and cost of automobile storage	Considerable encouragement	Considerable discouragement	Limited effect	Considerable encouragement	Moderate discouragement	Considerable discouragement	Limited effect
Cargo needs of trip	Limited effect	Moderate discouragement	Limited effect	Moderate discouragement	Limited effect	Moderate discouragement	Limited effect
Street congestion	Considerable encouragement	Moderate discouragement	Limited effect	Moderate encouragement	Moderate discouragement	Moderate discouragement	Moderate discouragement
Quality of pedestrian system	Limited effect	Considerable encouragement	Moderate encouragement	Moderate encouragement	Considerable encouragement	Moderate encouragement	Moderate encouragement
Transit availability	Moderate discouragement	Considerable encouragement	Moderate discouragement	Moderate encouragement	Moderate encouragement	Considerable encouragement	Moderate encouragement

[a]Trip to a recreational activity as opposed to a recreational bicycle trip.

Table 2. Cumulative percentage of home-based trips by time and purpose.

Trip Time (min)	Trip Purpose: Shopping	Personal Business	Recreation	School	Work	Medical
0 to 6	48.6	40.5	35.8	20.1	18.9	14.0
6 to 12	73.1	64.4	57.7	45.2	38.2	34.8
12 to 18	86.5	80.1	73.5	65.7	58.6	58.9
18 to 24	89.7	85.4	78.3	74.2	68.0	69.5
24 to 30	96.5	94.5	91.9	88.9	86.9	86.6
30 to 36	97.3	95.6	93.6	91.7	90.8	90.1
36 to 42	98.0	97.1	95.7	94.1	94.6	93.9

Table 3. Vehicular trips that can be attracted to the bicycle in the Minneapolis-St. Paul Metropolitan Area.

Trip Purpose	Total Daily Home-Based Vehicular Trips	Percentage of Vehicular Trips Less Than 6 Min Long[a]	Percentage of Trips Less Than 6 Min Long That Can Be Made by Bicycle	Trips Attracted to Bicycle if Proper Facilities Were Provided: Percent	Number
School	160,000	20.1	50.0	10.0	16,000
Recreation	817,000	35.0	35.0	12.0	100,000
Personal business	666,000	40.5	30.0	12.0	81,000
Shopping	566,000	48.6	20.0	9.7	55,000
Work	829,000	18.9	10.0	2.0	16,000
Medical	48,000	14.0	5.0	—	0
Total	3,086,000			8.7	268,000

[a]Based on an automobile operating speed of 20 mph (32 km/h) and equivalent to a 2-mile (3.2-km) bicycle trip.

Table 4. Home-based vehicular trips in 1970 in Minneapolis-St. Paul by purpose and mode.

Trip Purpose	Assumed Percentage of Bicycle Trips	Percentage of Trips by Present Mode: Automobile Driver	Automobile Passenger	Transit	Miscellaneous	Impact on Present Modes
Personal business	12.0	71.3	22.9	1.9	3.9	Reduce automobile passengers and drivers
Recreation	12.0	39.1	57.1	0.9	2.9	Reduce automobile passengers
School	10.0	15.7	20.5	4.6	59.2[a]	Reduce school bus trips and automobile passengers
Shopping	9.7	64.6	31.3	1.2	2.9	Reduce automobile drivers
Work	2.0	75.7	14.3	5.4	4.6	Reduce automobile passengers and transit users
Medical	—	47.7	40.8	8.8	2.7	—

[a]Includes trips by truck, motorcycle, and school bus.

BICYCLE ACCESS TO TRANSIT STATIONS

The typical conditions given in Table 1 for each trip purpose can, of course, change. As these typical conditions change, the probability of bicycle use fluctuates. An investigation of all the variations cannot be undertaken in a paper of this length, but an analysis of one change affecting the work trip is valuable. This change is a rapid transit system (rail or bus) within a metropolitan region and the resulting effect on bicycle use. Our concern is with the method of access to the transit stations and not the entire work trip made by transit.

There are four typical methods of access to transit stations: (a) walking, (b) feeder bus service, (c) park-and-ride, and (d) kiss-and-ride. The problem with kiss-and-ride is that it requires a driver to deliver the passenger to the transit station. Park-and-ride demands that an automobile be left at the station for the entire day. This can prove to be inconvenient or unacceptable if the family has only one automobile. Access by feeder bus can be time-consuming depending on the routing and schedules. Walking is limited to a distance of ½ mile (0.8 km).

In each of these situations, the bicycle has advantages over the other methods. It may be faster and more convenient than the feeder bus because it provides door-to-door service. If the bicycle is used instead of the park-and-ride mode, the family car is free for other uses. By using the bicycle, the transit patron who usually depends on the kiss-and-ride procedure is independent of the driver. Those who walk to transit stations are not expected to traverse a distance greater than ½ mile (0.8 km). The bicycle is an ideal access mode up to a distance of 2 miles (3.2 km). The ½-mile radius results in an area of 0.8 mile^2 (2 km^2) accessible to the pedestrian. The use of the bicycle for a trip up to 2 miles increases this area to 12.6 mile^2 (32.6 km^2), an area approximately 16 times as great. Those individuals within this area not having access to a car would find the bicycle ideally suited for a trip of this length.

Evaluation of the number of access trips that might be made by the bicycle should take into consideration many existing conditions, such as residential density within the 2-mile service areas of the bicycle. In conjunction with these elements, the other typical conditions given in Table 1 should be reviewed. The degree of encouragement or discouragement can have similar effects on the probability that the access trip will be made by bicycle.

ESTIMATING TRIP VOLUME

Based on trip length, flexibility, and other factors (Table 1), an estimation was made of the percentage of trips by purpose that could be made by bicycle. These estimates are given in Table 3. Of the 3,000,000 daily home-based vehicular trips made in the study area, the bicycle has a strong probability of attracting 268,000 trips. To put this into perspective, the transit system in Minneapolis and St. Paul attracted only 163,000 passengers daily in 1970. Bicycle trips would account for 8.7 percent of total home-based vehicular trips. The volume would be increased if those trips being made from non-home-based origins and recreational bicycle trips were also included.

There are substantial differences in the percentages of trips attracted to the bicycle for varying trip purposes. Fifty percent of school trips currently made by motorized vehicles can be made by bicycle, but only 10 percent of the work trips are less than 2 miles long. The majority of trips that can be made by bicycle are recreational and personal business trips.

IMPACT OF MODAL SPLIT

Using the bicycle for purposeful trips may generate new trips, but it is more likely that certain trips now made by automobile or transit will be made by bicycle. Thus, a change in the modal split will result. A breakdown of the 1970 modal split in the study area is given in Table 4, including the assumed percentage of trips made by bicycle by trip purpose. The conclusions stated in that table summarize the present form of transportation from which bicycle trips are likely to be attracted.

The greatest number of bicycle trips will be drawn from the present automobile passenger trips. The automobile passenger in many ways must be considered a captive rider. Currently, numerous trips are made just to accommodate the passenger. This number, in many instances, is as high as 10 percent of total automobile trips in a metropolitan area. If an alternative is available to the passenger, the driver might insist the passenger take advantage of this mode. Since, in many cases, the scheduling of these trips is based on the schedule of the driver the passenger may find it more convenient to use a bicycle.

A much smaller number of trips will be derived from present transit patrons. The door-to-door service of the bicycle is a distinct advantage over transit, which may require walking, waiting, and transferring to complete a trip. Due to the rather meager volume of transit patrons at present (2.7 percent of home-based trips) and the inclusion within this group of a large number of elderly people and commuters, the change of mode will not be very substantial. The transit riders who would be attracted to the bicycle are students and individuals who cannot afford an automobile but are physically able to use a bicycle.

The probability of drawing trips from the school bus is high if bicycle facilities are available. This would not be true for cross-town busing, but would affect the number of children being bused because they live beyond a reasonable walking distance.

Thus, it can be expected that, if a comprehensive system of bicycle facilities were built in the study area, a substantial number of purposeful trips would be made by bicycle. The majority of these trips would be made for recreational, personal business, school, and shopping purposes. The present modes that would show a reduction in use would be the automobile when used to serve the passenger, school bus when the trip is less than two miles in length, and transit.

CONCLUSIONS

1. The best candidates for purposeful bicycle trips are probably those who do not have ready access to an automobile. There are numerous instances during the course of a day when members of the family may not have ready access to the family car (or cars). In those and similar cases, the option of a short bicycle trip might be more attractive than either delaying the trip until an automobile is available or using public transit whose schedules and routes may not be convenient. This may have the side effect of reducing the significant number of automobile trips that are taken solely for the convenience of the automobile passenger.

2. The benefits of investing in commuter biking facilities may not be so significant as the benefits of investing in convenience biking. The commuter trip is typically the longest of all urban trips, must be performed on a rigid schedule, and has the best transit option. These factors pose a serious question of whether first-priority bicycle facility investments should be directed toward accommodating the commuter. A considerably larger number of convenience trips such as shopping and personal business trips might be more readily accommodated at less expense. However, the potential of bicycle commuting shows enough promise to give it a much better chance than currently exists in any major city. A pilot study of a high-quality system in a selected city would be beneficial. Development of a system focusing on a transit station would provide valuable information on the use of the bicycle as an access mode.

3. Bicycle ridership for purposeful trip making could exceed public transit ridership in most U.S. cities. If a safe and convenient bicycle system were provided, bicycle usage could outstrip public transit usage, in most cities, even if all purposeful bicycle trips were restricted to a distance of less than 2 miles (3.2 km). Consequently, as transportation funding for modes other than the automobile increases, the bicycle should receive serious consideration. Although the bicycle and public transit modes are primarily middle distance forms of urban transportation, they are largely complementary. Public transit is most useful in carrying large numbers of people to concentrated points, but the bicycle is better suited to moving smaller numbers of people to dispersed points.