are necessary if we are to better understand bicyclist behavior, in general, and the specifics of gap acceptance, queuing arrangements, and the like.

The impression conveyed in the paper is that gap acceptance is for varying conditions but, in actuality, only two locations were examined. According to Table 6, only locations 1 and 2 were observed, and both are in East Lansing campus situations. Yet reference to Table 4 indicates that location 1 is a lane and a path, and that location 2 is a path, a lane, and a sidewalk. It is our contention that gap acceptance will vary with each condition, and thus values should not be aggregated, as in Table 6. Values should be established for each type of bicycle facility.

Further, there is mention of "bicycle crossing of two lanes of motor vehicle traffic [7.3 m (24 ft) wide]." But crossing two lanes of one-way traffic is simply not the same as crossing one lane each of traffic moving in opposite directions. The data are useful for specific situations but can be taken no further.

Other questions that might have been asked are: Do the bicyclists cross at the same location as pedestrians? Do they cross from a path to a street or from a lane to a lane? Better sense could be made of the results had we been provided with more essential details.

These details also color any conclusions that might be drawn about the effects of bicycles on motor vehicular speeds. Information as to the widths of the roadway, motor vehicle lanes, and bicycle lanes is necessary before better sense can be made as to bicycle speeds. The paper states that bicycle speeds were highest on the bicycle lanes [mean 24.9 km/h (15.5 mph)], whereas on streets without bicycle lanes, bicycle speeds were lower, 19.0 km/h (11.8 mph) average. We need to know what the lane widths were in each situation. We would hypothesize that bicycle speeds are higher in wider motor vehicle curb lanes. Information as to vehicular volumes is also desirable, as the number, and type, of motor vehicles have a definite effect on bicycle speeds.

Another behavioral question is raised by the fact that all the data were collected in the proximity of college campuses. The authors acknowledge that this "proximity to campuses introduces a bias to the young adult age group." Other biases may also be introduced. The motor vehicle operators with whom the bicyclists interact may more likely be college students as well, so age selectivity and personal familiarity with bicycle operation might be considered as further influential factors.

In sum, the paper has much general value, yet more needs to be made explicit. The investigative techniques appear to be useful, and much thought has been given to how to best compile and analyze data. Yet the heart of the matter—the urban intersections themselves—are inadequately analyzed and categorized.

One observation in the introductory literature review illustrates the need to be discrete. The authors cite Ferrara's work on intersection behavior in California, "an environment", we are told, "largely conducive to the use of the bicycle." But there are a multitude of "Californias", northern and southern, coastal and interior, bicycle oriented and automobile oriented. Similarly, there are many kinds of intersections. We need stricter guidelines and fewer generalizations before better sense is to be made of bicycle traffic at urban intersections.

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Strategies for Increasing Levels of Walking and Bicycling for Utilitarian Purposes

Ferrol O. Robinson, Jerry L. Edwards, and Carl E. Ohrn

This paper reports the results of an extensive survey of motorized and nonmotorized travel. The survey was conducted in connection with a study to (a) identify problems associated with walking and bicycling, (b) identify a wide range of incentives to promote the use of walking and bicycling for utilitarian trip purposes, and (c) establish the cost-effectiveness of the incentives identified. This paper limits itself to an analysis of the survey results as they relate to the topics of (a) trip and trip-maker characteristics, (b) mode choice and mode preference, and (c) changes in preference for alternative modes of travel in response to the implementation of selected scenarios. The scenarios tested were (a) provision of bicycle and pedestrian facilities, (b) fee on automobile use during peak periods, (c) compact land-use setting with provision of pedestrian and bicycle facilities, and (d) increases in fuel prices. The survey responses indicate that a compact land-use arrangement, combined with the provision of pedestrian and bicycle facilities, has the greatest potential for creating a shift from the automobile to walking and bicycling. Bicycle and pedestrian facilities alone follow in importance. A fee on automobile use during peak periods has the effect of reducing automobile use; however, one-third to one-half of the trips diverted go to transit rather than to nonmotorized modes. Finally, doubling the price of fuel appears to be the least effective of the strategies analyzed for increasing walking and bicycling.

The importance of walking and bicycling for utilitarian travel has long been recognized in many countries (1, 2). However, only in the past several years has interest grown in nonmotorized modes in the United States. This interest has been generated, to a large extent, by economic, social, and environmental concerns related to the negative effects of widespread use of the automobile. At present, however, the general public, as well as public officials, are skeptical about the feasibility of nonmotorized modes as means of transportation and the advisability of investing public dollars to encourage their use. It is important, therefore, to determine as clearly as possible the extent to which a mode shift from the automobile to nonmotorized modes can be achieved if we invest public money in a variety of strategies.

This paper explores the potential of various strategies for increasing the demand for nonmotorized travel. Estimates of changes in modal share are developed

Table 1. Summary of survey contacts.

City	Not at Home	No Qualified Respondent at Home	Refusals	Placements	Total
Austin	1739	88	180	1380	3 387
Columbus	1650	195	246	1380	3 471
Denver	2742	294	609	1380	5 025
Huntington Beach	947	231	277	1380	2 835
Philadelphia	1066	99	208	1380	2 753
Total	8144	907	1520	6900	17 471

Table 2. Summary of survey placements.

City	Not Returned	Unused Returns	Processed	Total
Austin	441	139	800	1380
Columbus	490	90	800	1380
Denver	418	162	800	1380
Huntington Beach	510	70	800	1380
Philadelphia	673	41	666	1380
Total	2532	502	3866	6900

based on respondents' ranking of alternative modes after the introduction of each scenario or strategy. Current mode choice and its relation to current modal preference and to trip and trip-maker characteristics are analyzed.

SURVEY DESCRIPTION

To accomplish the objectives of the study, a self-administered attitudinal and market research survey was designed. A number of guidelines and constraints were established at the outset to ensure that the survey effort would focus on the types of trips and population groups that exhibit the greatest potential for use of nonmotorized modes. The following decisions affect the results of the survey and should be kept in mind while examining the results presented here:

1. The study examines users of all major transportation modes (automobile, transit, bicycle, and walk); however, special attention is given to automobile users because they represent the largest share of utilitarian trip making. Thus, strategies aimed at increasing nonmotorized travel must take into account the needs of automobile users.
2. The surveys focus on utilitarian trips, specifically work, shopping, personal business, and college-level school trips rather than recreation trips.
3. Given the limited cargo-carrying capacity of nonmotorized modes, major shopping trips, involving heavy or large cargo, were excluded.
4. Emphasis is placed on home-based trips since the decision to bicycle or to walk rather than to take the car is made at the home end.
5. The survey was administered to persons 16 years and older. Younger persons are currently significant users of nonmotorized modes for school and shopping trips and are not viewed as having significant potential for a mode shift away from automobile.
6. Given the dominance of short trip length in nonmotorized travel, rating and ranking of modes was constrained to work trips that were within 4.8 km (3 miles) for walking and 9.6 km (6 miles) for bicycling and to shopping and personal business trips that were within 3.2 km (2 miles) and 6.4 km (4 miles) for walking and bicycling, respectively.

Survey Methodology

The survey instruments were designed to be self-administered. All questionnaires were hand-delivered by trained field interviewers to households preselected randomly within the selected geographic areas. This method of delivery, sometimes referred to as the drop-off, pick-up technique, has the advantage of giving the field worker the opportunity to explain the purpose of the study, to review the survey form, to answer questions, and, in general, to engage the cooperation of the potential respondent to the survey.

When the questionnaire was dropped off, the interviewer agreed with the respondent on a date (usually within three to four days) when the questionnaire would be ready for pickup. To increase the rate of return, a reminder postcard was mailed to each participating household on the day following placement. On returning to the household on the day specified for pickup, if the respondent was not at home or had not completed the questionnaire, a second attempt was made to collect the form. If at this point no contact was made, a preaddressed, postage-prepaid envelope was left with instructions that the questionnaire be returned by mail. Contacts were made during the day as well as during evening hours, and approximately one-half of the questionnaires were placed with male members of the household and one-half with females 16 years of age or older.

Tables 1 and 2 summarize the returns. A total of 17 471 households were contacted in the five geographic areas, and 6900 questionnaires were placed with potential respondents. Of the surveys placed, 4368 or 63.3 percent were returned, and 3866 were finally processed.

Given the length of the survey questionnaire (16-18 pages), the return rate of 63.3 percent is quite acceptable when compared with surveys of similar length (3). Several factors are seen as contributing to this result. First, the drop-off, pick-up technique has been found to elicit a greater rate of return than a mail survey. Second, the forms were attractive, printed clearly, identified with each city's letterhead, and accompanied by an introductory letter signed by a city official. Finally, the reminder postcard, second visit, and preaddressed and stamped return envelope are all seen as contributing factors to the rate of return obtained.

Geographic Areas Surveyed

Five geographic areas that represent various regions within the United States were surveyed. Within each area, specific sites [10-15 km^2 (4-6 $miles^2$) in size] were selected according to the set of criteria described below for each site.

Austin

Two residential sites connected with the University of Texas campus were surveyed. One site corresponds to the residential area located north and west of campus, characterized by renter-occupied apartments and single-family homes. This site is located within 1.6 km (1 mile) of the central business district (CBD) and contains bicycle lanes and an extensive sidewalk network. The area contains many shopping opportunities and the university itself is a major employer. The second site is composed of university student housing, and it is located within 10 km (6 miles) of the campus.

Columbus, Indiana

Columbus represents a small city site. The area surveyed included most of the contiguous built-up section of the city. The area is characterized by single-family, owner-occupied housing, major industrial plants, CBD, and strip commercial area. There are sidewalks in about one-half of the area and very few bicycle paths and lanes.

Denver

A central city site was selected in Denver. The site is located southeast of the CBD and within 8 km (5 miles) of it. The area is made up mainly of single-family homes and small apartments. There are sidewalks throughout the area as well as an extensive system of bicycle paths and lanes.

Huntington Beach, California

This area represents a suburban site and is 19 km (12 miles) away from the nearest center, Long Beach. The 7.8-km^2 (3-$mile^2$) site selected in Huntington Beach is located west of the city and is characterized by single-family housing, nearby schools, a light-industry district, and a community shopping center.

Philadelphia

Two neighborhoods, located within 1.6 km of the CBD, were selected to represent fringe sites. Society Hill and Rittenhouse are characterized by rowhouses and high-rise apartments, large concentrations of employment and commercial activity nearby, extensive pedestrian facilities and walking activity, and limited bicycle facilities.

The areas surveyed were selected because they offered specific features that were considered beneficial to the purposes of the study. The most important characteristic included their location near a variety of walking and bicycling opportunities for work, school, shopping, and personal business trips; the socioeconomic characteristics of residents; and the mixture of housing types and densities. In general, all areas had sidewalks, but only three of the sites had extensive systems of bicycling facilities.

The five sites represent a spectrum of urban environments, which ranged from a small city to an inner city neighborhood of a major metropolitan area. This intentional factor allows the potential transfer of data to a large segment of areas by identifying areas and population groups that exhibit similar characteristics.

SURVEY RESULTS

The remainder of this paper will examine the results of the survey as they relate to current mode choices, their relationship to characteristics of the trip and the trip maker, and a comparison between mode choice and modal preference. Finally, changes in modal preference in response to hypothetical scenarios designed to act either as disincentives to automobile use or as incentives to nonmotorized use are analyzed.

Trip-Maker Characteristics

A summary of socioeconomic characteristics of respondents is presented in Table 3. Table 3 reveals an overrepresentation of females for shopping and personal business trips, particularly in Columbus and Philadelphia. Overall, the distribution of both automobile and walk trips between women and men is even (49 percent of women, 51 percent of men). On the other hand, two-thirds of the bicycle trips and one-third of bus trips were made by men.

Table 3 shows that the university area in Austin exhibits the lowest age profile. In terms of mode choice, there is a significant difference between the age of bicyclists and the age of users of other modes. Even excluding school trips, the average age for bicyclists on work and shopping-personal business trips is 32 and 29 years, respectively, versus 37 and 40 years for automobile.

The most common occupations encountered were professional-technical, blue collar, and housewife. Confirming the above finding about bicycle use by women, only 6 percent of bicycle trips are taken by housewives (versus 19 percent of automobile trips).

There appears to be a relationship between housing density and choice of mode. Survey responses reveal that 88 percent of automobile trips originate from low-density housing (single family, duplex, and townhouse), and only 12 percent originate from high-density housing (walk-up, low-rise and high-rise apartments). On the other hand, 56 percent of walk trips originate from low-density housing and 44 percent are from high-density units.

Automobile ownership is lower in the two cities that reported the highest use of nonmotorized modes. Philadelphia reported the lowest number of automobiles and the lowest use of the automobile for both the work and shopping-personal business trip purposes. This result is consistent with the relation found nationwide between automobile ownership and vehicle trips made (4). The relation between the number of automobiles owned and mode chosen is not significantly different between Columbus, Denver, and Huntington Beach. At an aggregate level, bicycle ownership is not an explanatory variable for choice of mode for either work or shopping-personal business trips. Huntington Beach reported the highest number of bicycles per household (2.2 bicycles compared to an average 1.5 for all cities); however, its choice of the bicycle was similar to that in other cities, excluding Austin. Bicycle ownership is average in Austin, but it reports the highest share of bicycle trips.

Trip Characteristics

Survey responses show that whenever three or more additional stops are made for the purpose of shopping-personal business, the choice of automobile is roughly twice as frequent as the choice of nonmotorized modes. Exceptions to this pattern are found in Philadelphia and Austin. In Philadelphia, more than 16 percent of shopping and personal business trips that include three or more additional stops were made by nonmotorized modes compared to 8 percent by automobile. These findings tend to support the contention that multiple stops do not exclude use of nonmotorized vehicles.

Although there is no significant difference among cities in the number of persons that accompany the traveler, there is a difference between modes regarding this characteristic. In fact, 28 percent of the automobile users in all communities had two or more additional persons in the vehicle when making shopping-personal business trips. Only 20 percent of those persons reporting nonmotorized trips for this purpose had two or more additional persons accompanying them.

People choose the period from 9:00 a.m. to 2:00 p.m. for making shopping-personal business trips regardless of mode. However, the situation in Austin is different. In Austin, the most frequent time for making such trips is between 2:00 and 6:00 p.m. This is true for both automobile users and those who walk. This most likely reflects the fact that students shop after class. By 6:00 p.m., nearly 91 percent of those who walk have made their trips, whereas 85 percent of automobile trips have been completed.

Distance is clearly a factor in the choice of mode, as can be seen from Table 4. In all cities, more than 90 percent of nonautomobile trips were 3.2 km (2 miles) or less in length. Only 18.3 percent of automobile trips are accomplished within a distance of 0.8 km (0.5 mile) whereas 63 percent are made within a distance of 3.2 km (2 miles) (assumed maximum distance for walking trips for shopping). Approximately 80 percent of automobile trips for shopping-personal business are 6.4 km (4 miles) or less (which is the assumed maximum distance for bicycling). This suggests a significant potential for future competition between automobile modes and nonmotorized modes within these trip distances.

Mode Choice and Preference

To determine how users evaluate the transportation services available to them, respondents were asked to rank their preferences for the existing modes. Table 5 shows the percentage of respondents who chose each mode as well as the percentage that ranked each mode as their most preferred. Examination of this table shows several patterns emerging. Preference is a good indicator of choice, as shown by the fact that 72 percent of respondents would prefer automobile for their trip to work and 75 percent actually do choose automobile. By using similar survey techniques, Koppelman, Hauser, and Tybout have reached similar conclusions regarding the relation between mode preference and choice (5); however, not everyone chooses the preferred mode. For example, overall 14 percent of respondents identified walk as their first preference, yet only 11 percent actually used it. In fact, in areas of high automobile use (Columbus, Denver, and Huntington Beach) a lower number of respondents indicate automobile as their preferred mode than actually choose it. In areas of low automobile use or, conversely, of high transit and walking activity (Austin and Philadelphia), a higher number of people show automobile as their preferred mode than actually choose it. On the

Table 3. Socioeconomic profile of respondents.

City	Trip Purpose	Male (%)	Female (%)	Age: Average	Age: Mode	Automobiles per Household	Bicycles per Household	Average Income ($)	Occupation: Most Frequent	%	Occupation: Next Most Frequent	%
Austin	School	50.7	49.3	24.0	21-25	1.7	1.3	14 842	-		-	
	Shopping or personal business (PB)	50.2	49.8	28.7	16-25	1.6	1.5	14 555	Student	29.8	Professional-Technical	29.3
Columbus	Work	55.0	45.0	38.2	36-50	1.9	1.6	19 270	Blue collar	31.3	Professional-Technical	26
	Shopping or PB	41.8	58.2	44.2	26-35	1.8	1.6	17 400	Housewife	22	Professional-Technical	16.5
Denver	Work	50.0	50.0	35.3	26-35	1.9	1.6	21 275	Professional-Technical	49	Blue Collar	17.8
	Shopping or PB	48.8	50.9	45.1	26-35	1.8	1.3	18 060	Professional-Technical	28.5	Housewife	15.5
Huntington Beach	Work	50.0	50.0	37.7	36-50	2.4	2.2	27 370	Professional-Technical	41.9	Secretarial-Clerk	18.3
	Shopping or PB	48.0	52.0	40.4	36-50	2.3	2.2	25 220	Housewife	27.0	Professional-Technical	26.3
Philadelphia	Work	51.7	48.3	37.7	26-35	1.0	1.0	31 975	Professional-Technical	64.1	Managerial	15.7
	Shopping or PB	42.7	57.0	40.3	26-35	0.9	1.1	29 970	Professional-Technical	46.3	Managerial	11.7
Total	School	50.7	49.3	24.0	21-25	1.7	1.3	14 842	-		-	
	Work	51.7	48.3	37.2	26-35	1.8	1.6	24 720	Professional-Technical	44.6	Blue Collar	17.6
	Shopping or PB	46.5	53.4	39.7	26-35	1.7	1.5	20 590	Professional-Technical	28.6	Housewife	15.9

Table 4. Cumulative percentages for distribution of trips by distance for shopping and personal business trips.

City	Mode	Distance: 0-0.40 km	0.41-0.80 km	0.81-1.60 km	1.61-3.20 km	3.21-6.40 km	6.41-9.60 km	9.61-16.00 km	16.00 + km
Austin	Automobile	4.7	18.7	40.0	57.4	82.5	91.4	98.0	100.0
	Nonautomobile	16.5	61.7	81.7	93.0	95.6	98.2	99.1	100.0
Columbus	Automobile	3.4	19.4	46.4	71.9	91.7	95.1	95.7	100.0
	Nonautomobile	15.2	72.8	94.0	97.0	100.0	100.0	100.0	100.0
Denver	Automobile	1.7	11.8	28.2	50.0	75.5	90.6	96.3	100.0
	Nonautomobile	26.7	73.3	80.0	93.3	96.6	98.3	100.0	100.0
Huntington Beach	Automobile	5.8	22.8	46.5	71.1	88.9	92.8	94.7	100.0
	Nonautomobile	40.0	73.3	83.3	100.0	100.0	100.0	100.0	100.0
Philadelphia	Automobile	0.0	15.7	35.2	50.9	62.7	74.5	84.3	100.0
	Nonautomobile	32.4	70.1	89.4	98.6	100.0	100.0	100.0	100.0

Note: 1 km = 0.6 mile.

Table 5. Summary percentages of modes chosen and preferred modes.

City	Purpose	Automobile		Walk		Transit		Bicycle		Other[a]	No
		Chosen	Preferred	Chosen	Preferred	Chosen	Preferred	Chosen	Preferred	Chosen	Response
Austin	School[b]	18	26	36	28	28	19	15	25	3	2
	Shopping-PB	64	62	23	19	6	5	6	14	1	
Columbus	Work	91	86	4	6	1	2	1	4	3	2
	Shopping-PB	87	86	7	5	2	2	1	4	3	3
Denver	Work	80	74	4	6	10	8	4	10	2	2
	Shopping-PB	74	73	13	11	10	8	2	6	1	2
Huntington Beach	Work	92	89	2	3	1	4	1	4	3	
	Shopping-PB	90	90	6	5	1	1	2	4	1	
Philadelphia	Work	29	34	35	44	26	10	4	9	6	3
	Shopping-PB	16	24	63	60	13	8	2	7	6	1
Total	Work	75	72	11	14	9	6	3	7	2	1
	Shopping-PB	68	69	21	18	6	5	3	7	2	1
	School	18	26	36	28	28	19	15	25	3	2

[a] Respondents were asked to rank preference for the four modes indicated.
[b] Survey of school trips was done in Austin only.

other hand, fewer respondents show walk and transit as their preferred modes than are currently using them. Of all modes, bicycle is the only one for which preference is consistently greater than choice. This is true regardless of the current level of bicycle use or the purpose of the trip.

These above findings indicate that, as a result of mode availability and individual circumstances, a certain number of captive users are associated with each mode. Policymakers could benefit from the knowledge of the conditions that would bring people's use of bicycle for utilitarian trips more in line with their indicated preference for bicycling. Later phases of the project will attempt to respond to this need.

TESTING OF SELECTED STRATEGIES

In keeping with the fundamental objective of the study, a set of scenarios was developed that is considered to contain many of the important factors that can explain potential shifts to nonmotorized modes. Because of questionnaire length and time constraints, the strategies tested in the survey were limited to the following:

1. Provision of improved pedestrian facilities (sidewalks, pathways, and ancillary facilities);
2. Provision of improved bicycle facilities (bikeways, bicycle lanes, and ancillary bicycle facilities);
3. Implementation of pricing mechanism to discourage vehicular traffic in the downtown areas during peak periods (congestion fee; availability of flexible work hours was also tested concurrently with the congestion-fee strategy);
4. Encouragement of self-contained development where trip generators are in relatively close proximity to each other (compact land use; also tested with this strategy were lowering of speed limits and reduction of parking-space availability); and
5. Increases in fuel prices (fuel price increases were tested alone as well as in combination with the above strategies).

The major strategies tested were presented in the form of stretcher scenarios. The technique of stretcher scenarios, described by Urban and Hauser (6), involves brief descriptions of hypothetical scenarios that span the range of new transportation alternatives. By use of consumer preference responses to the stretcher scenarios, it is possible to interpolate consumer preferences to alternative future conditions that lie between current conditions and the stretchers, rather than merely extrapolating from current conditions.

After each of the strategies listed above was described, respondents were asked to rank their order of preference for the four modes examined. The changes in preference can be interpreted as the result of people's rearrangement of their perceptions of the attributes of the various modes in response to the innovations. Therefore, a common finding in attitudinal studies is that stated intentions or preferences do not always agree with subsequent behavior (7). In fact, stated preferences have tended to overestimate actual mode shifts (8). Therefore, the responses should be interpreted as indicative of the relative shifts that might be accomplished when comparing alternate strategies. The absolute value of the resulting shift to nonmotorized modes not only represents extreme values attainable only under the hypothetical conditions described in the statement, but may also include an overestimate of actual shifts due to the inability of respondents to predict future behavior accurately. Subsequent development of perception and preference models are likely to provide a truer measure of the magnitude of modal shifts that can realistically be expected to occur.

Each scenario will be described next, followed by an analysis of its effect on modal preference, where effects are measured in terms of the degree of change from current preferences.

Compact Land-Use Scenario

The description of this concept statement read as follows:

Living Nearer to Travel Destinations

Many planners maintain that the use of automobiles has greatly increased the levels of air pollution, energy consumption, traffic congestion, and costly street and highway expenditures. It has been suggested that, in order to reduce these problems, people must live nearer to their places of employment, shopping, school, and recreation.

Some communities have been designed with this compact land-use arrangement in mind. Their layout is such that most shopping and personal business trips can be accommodated within a six-block [0.5 mile (0.8 km)] distance and most work trips are within 2 miles [3.2 km] of home.

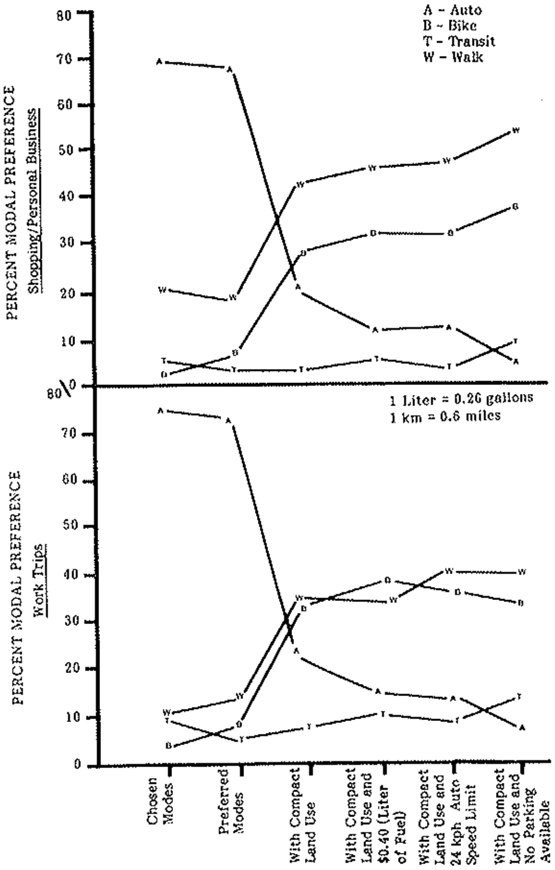
Suppose you live or moved to one such community. Suppose further that special bicycle paths and pedestrian pathways are provided so that it is possible to walk or bicycle to all shopping and personal business destinations without having to cross streets that carry heavy motor vehicle traffic; bicycle storing and lock-up facilities are provided in large numbers, free of charge, throughout the area; convenient bus service is available; and there are no special restrictions on the use of automobiles.

Table 6. Effect of strategies on modal preference, expressed as percentages of those choosing each mode.

Mode	Current Performance		With Improved Pedestrian Facilities		With Improved Bicycle Facilities		With Congestion Fee of $2.00		With Compact Land Use		With Increase in Fuel Price of $0.40/L	
	Work	Shopping-PB	Work	Shopping-PB	Work	Shopping-PB	Work	Shopping-PB	Work	Shopping-PB	Work	Shopping-PB
Automobile	72	69	52	51	56	56	42	32	23	20	47	36
Walk	14	18	30	33	17	17	18	28	34	45	16	25
Bicycle	7	7	10	10	18	21	16	19	33	29	14	13
Transit	6	6	5	3	5	4	21	17	7	4	12	19

Note: 1 L = 0.26 gal.

Figure 1. Effect of compact land use plus fuel price increases and restricted speed and parking.



This statement contains two main elements that explain why such a scenario is responsible for the highest shifts from the automobile to walking and bicycling (see Table 6). These two elements are (a) acceptable distances for walking and bicycling and (b) walking and bicycling facilities separated from motorized traffic.

As can be seen from Figure 1 and Table 6, the number of respondents who select automobile as their preferred mode is reduced significantly (although not shown, the shift is particularly dramatic for Denver, Columbus, and Huntington Beach; even in Philadelphia, where automobile usage is relatively low, the shift in preference from automobile to nonmotorized modes is appreciable).

Although these results might seem unrealistic at first glance, it should be noted that, at present, the neighborhoods surveyed in Philadelphia (both of which exhibit short walk distance to the employment center and extensive sidewalk networks) show a significant amount of walking activity. In these neighborhoods, approximately 40 percent of respondents to the work survey, and 65 percent of the respondents to the shopping-personal business survey, walked to their destination. The 1970 census shows that 44 percent of those who work in Center City live within 9.6 km (6 miles) of City Hall, 30 percent live within 6.4 km (4 miles), and 14 percent live within 3.2 km (2 miles). A survey conducted in 1973 indicated that, assuming bicycle lanes and bicycle parking were available, 38 percent of bicycle owners and 17 percent of nonowners would commute to work (9). This result is consistent with our survey, which shows approximately a 30 percent preference level for bicycle under the compact land-use scenario that includes bicycle paths and lanes as well as parking facilities. The importance of bicycle facilities for attracting utilitarian trips, when provided in connection with specific compact land uses, such as university campuses and CBDs, has been recognized and documented (10-12).

Whether changes in land-use distribution can be accomplished in areas such as Huntington Beach in order to increase nonmotorized level of use significantly is a matter for further analysis. It appears, however, that residents of the area perceive such arrangements as conducive to reducing dependence on the automobile. It is interesting to note that in response to the direction to indicate their agreement or disagreement with the statement, "I would like to live in this type of community," in reference to the compact land-use concept statement, approximately 70 percent of all persons surveyed either agreed or strongly agreed with the above statement.

The effect on mode shift of combining an increase in fuel price [$0.40/L ($1.50/gal)] with the compact land-use scheme is only marginal (see Figure 1). Most of the shift is accomplished with the land-use concept and only an additional 5-10 percent of the respondents indicate that they would shift their preference from automobile to nonmotorized modes with the juxtaposition of the increase in gasoline prices. The superposition of a speed limit of 24 km/h (15 mph) on the compact land-use concept has no detectable effect on mode shift. This is probably because, under such a land-use arrangement, respondents might reason that trips are quite short and, thus, attaining high speeds becomes unnecessary. Restricting the availability of parking in the land-use arrangement concept causes approximately a 10 percent shift in the number of respondents that select automobile as their first preference. This shift is taken up by the remaining modes.

Improvement of Bicycle Facilities Scenario

The following concept statement related to improvements in bicycle facilities was included in the survey questionnaire:

Figure 2. Effect of improved bicycle facilities plus increased fuel prices.

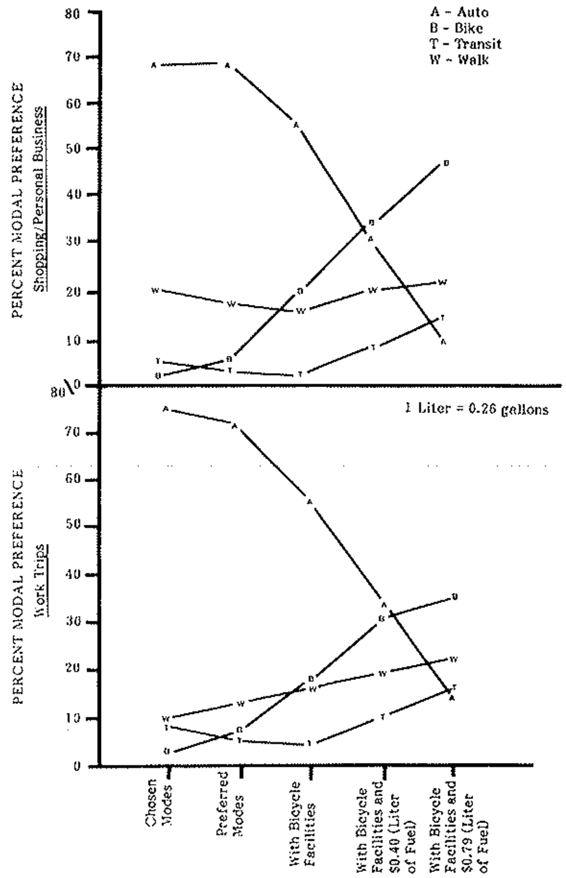
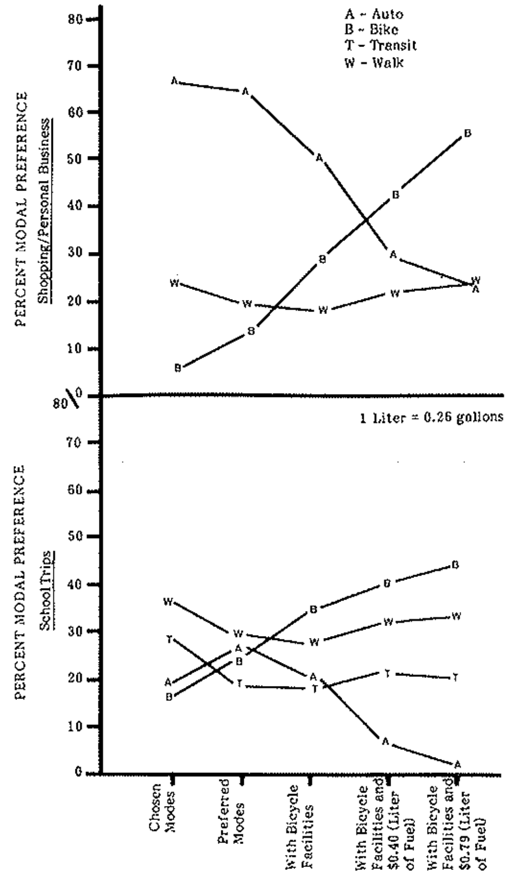


Figure 3. Effect of improved bicycle facilities plus increased fuel prices—Austin.



Bicycle-Related Facility Improvements

Suppose the city introduces several improvements to bicycle-related facilities designed to increase the comfort and safety of cyclists. The improvements consist of (a) providing bicycle paths, (b) reserving street lanes for bicycle use, (c) improving road surfaces, (d) installing secure bicycle lock-up facilities in many areas, and (e) providing better lighting.

On most local streets, a yellow stripe is painted near the right-hand side of the road marking a lane reserved strictly for bicycle use. Separate bicycle paths are built adjacent to all major roadways. These bicycle paths are separated from automobile traffic by a metal guardrail or a grass median. All these paths and street lanes are smoothly paved for better riding. In addition, high-intensity lights are added along the bikeways to provide excellent visibility at night. A large number of secure bike lock-up facilities are provided and, in high-activity areas, these consist of enclosed storage lockers manned by a full-time attendant. Finally, convenient locker, shower, and changing facilities are made freely available.

Respondents were then directed to indicate their ranked preference for the four major modes (automobile, bicycle, transit, and walk). Results are plotted in Figure 2. The current mode split (chosen mode) as well as the preferred modes are also plotted for reference purposes.

On the basis of the concept statement given above, 15-20 percent of the respondents shifted their preferred mode from automobile to bicycle. The pattern of decreased automobile use and increased bicycle use is consistent, generally, among the areas surveyed. However, Austin, which currently exhibits a relatively high level of bicycle use, appears to have the greatest potential for increased shift to the bicycle (see Figure 3). This is clearly a result of the proximity of the university for school trips, the availability of shopping-personal business opportunities nearby, and a familiarity of current bicycle use. The element of social acceptability appears to play an important role in the propensity for increased bicycle use. The relationship between high bicycle use for utilitarian purposes and the availability of bicycle paths and lanes has been documented previously (1, 13).

To determine the simultaneous effect of bicycle facility improvement and fuel price increase, survey participants were asked to repeat the ranking of modes with bicycle facilities in place, but assuming also that the price of fuel doubled to \$0.40/L and \$0.80/L (\$1.50/gal and \$3.00/gal). The additional burden placed on automobile use by the added fuel cost has the effect of reducing the number of respondents that select automobile as their preferred mode. At the \$0.40/L price level, approximately 25 percent of the respondents to the shopping-personal business survey shifted their preference from automobile to other modes (15 percent shifted their preference to bicycle, and the other 10 percent selected walk and transit). On the work-trip survey, 20 percent of the respondents shifted their preference to other modes (13 percent to bicycle and 7 percent to walk and transit). Almost identical results are obtained when the fuel price increases to \$0.80/L as were obtained above for work trips.

Improvement of Pedestrian Facilities Scenario

The survey contained the following stretcher scenario related to the improvement of pedestrian facilities:

Suppose the city introduces several improvements to pedestrian-related facilities designed to increase the comfort and safety of pedestrians. The improvements consist of (a) providing pedestrian pathways, (b) improving sidewalks, (c) providing better lighting, and (d) making traffic signals more pedestrian-oriented.

Separate pedestrianways or walkways are built adjacent to all major roadways. These pathways are separated from automobile traffic by trees or grass median. At all busy street crossings, pedestrians will be able to change traffic lights in their favor. All existing sidewalks are repaired to make walking easier. High-intensity lights are added along the pathways to provide excellent visibility at night. Finally, the walkways are enhanced by the presence of water fountains, shade trees, benches, and pedestrian-oriented stands with flowers, newspapers, and refreshments.

Respondents were directed to proceed with the questions related to this statement only if their most recent trip destination was within the distance limit for walking—3.2 km (2 miles) for shopping-personal business, and 4.8 km (3 miles) for work. The respondents were then asked to rank the four major modes, assuming that the improved pedestrian facilities were in place. The results are plotted in Figure 4 and summarized in Table 6. On the average, 15-20 percent of those now using automobile indicate that they will switch to walking if the pedestrian facilities are in place.

While differences exist, it is interesting to note the similarity and consistency of response found among the different areas and trip purposes surveyed. In the areas surrounding the University of Texas and in Philadelphia, where there is a significant amount of walking at present, the effect of providing the improved facilities for walking is to shift an additional 15-20 percent of the automobile users to walking (this is illustrated in Figure 5 for the Philadelphia sites). In contrast, results in Huntington Beach show that only about 5 percent of the automobile trips will shift to walking. As indicated earlier, there is heavy dependency on the automobile in Huntington Beach because of the suburban nature of that area, which no doubt explains in part the low propensity for walking found there. This finding is similar to that encountered for the bicycle facilities scenario: The greater the current level of walking, the greater is the potential for increased walking. The corollary is that the greater the level of automobile use, the greater will be the tendency for continued automobile use. A peculiar finding is that a slight diversion of automobile trips to bicycling is observed (on the order of 5 percent), although no specific mention is made of bicycles in the pedestrian-facilities concept statement. Apparently some respondents are assuming that the pedestrian paths and ancillary facilities will be available to bicyclists.

In general, the simultaneous provision of pedestrian facilities and fuel price increases have the effect of shifting additional trips from automobile to all other modes, but particularly to nonmotorized modes. Over all areas surveyed, about 20 percent of respondents to the work-trip survey shift from automobile when fuel price is \$0.40/L, and an additional 20 percent shift at \$0.80/L. The shopping-personal business survey shows a shift of 25 percent at \$0.40/L and 15 percent at \$0.80/L. These reductions in automobile use are somewhat higher than when fuel pricing alone is tested. The increased fuel price in areas where walking is currently at a high level has a negligible effect on the amount of walking that is already taking place. Instead,

Figure 4. Effect of improved pedestrian facilities plus increased fuel prices.

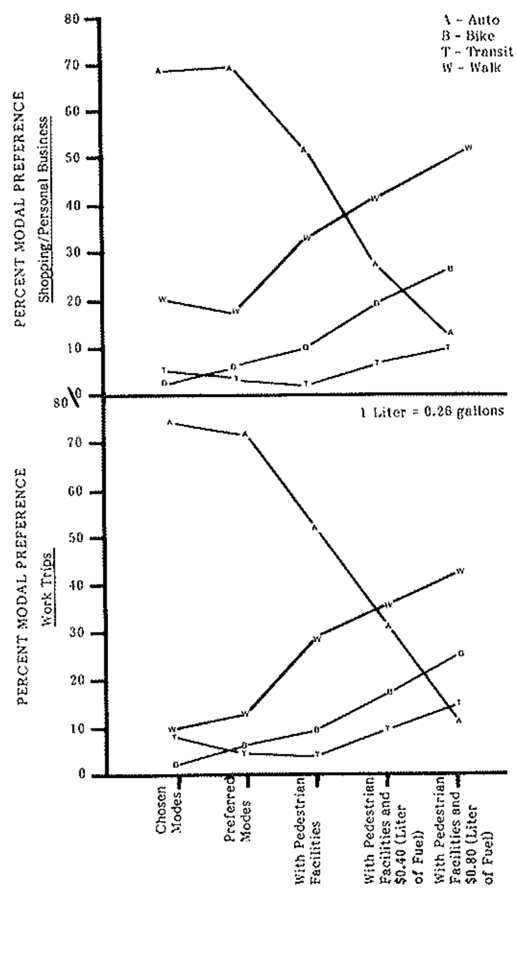
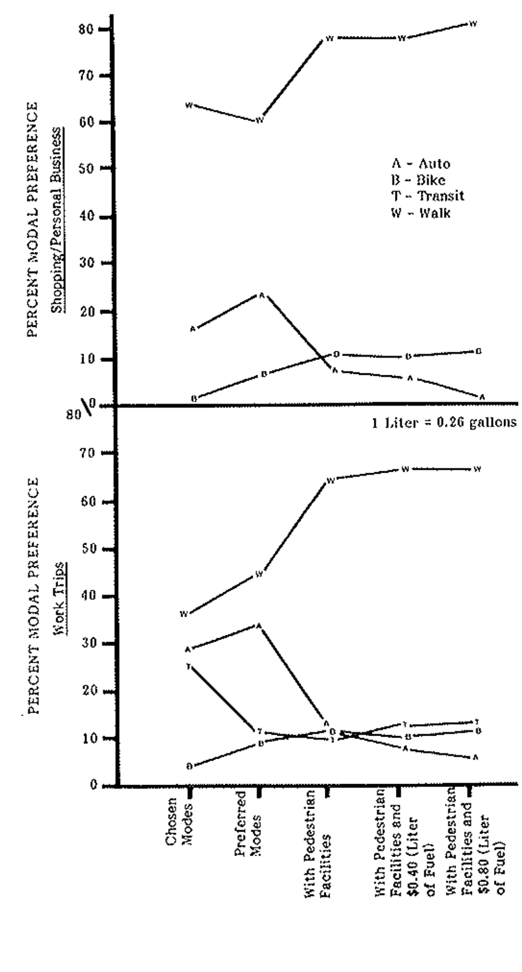


Figure 5. Effect of improved pedestrian facilities plus increased fuel prices—Philadelphia.



the reduction in automobile usage is taken up by increased bicycle and transit usage.

Automobile Congestion-Fee Scenario

In order to test the effect of implementing policies that can act as disincentives to automobile use and thus cause shifts to nonmotorized use, the following concept statement was included in the survey questionnaire:

Automobile Congestion Fee

It is decided that, in order to reduce congestion and lower fuel usage, a fee of $1 will be assessed to the owners of automobiles operating during the morning (7:00-9:00 a.m.) and evening (4:00-6:00 p.m.) rush hours. This means that you would be charged up to a $2.00/day if you operate a motor vehicle during these peak travel periods. Billing would be made on a monthly basis using an automated billing process.

As with the preceding concept statement, respondents were directed to rank the modes in order of preference. The resulting modal distribution is plotted in Figure 6 and summarized in Table 6.

The congestion-fee strategy has the potential for effecting significant shifts away from automobile. A congestion fee of $2.00/day causes a reduction of 35 percent in the number of respondents who select automobile as their preferred alternative. Walk and bicycle take up most of this shift for the shopping-personal business trips; for the work trips, transit takes up half of the shift and the nonmotorized modes account for the other half. The pattern of decrease in automobile usage due to the congestion fee of $2.00/day is fairly predictable from area to area except for work-trips responses in Huntington Beach. Although about 30 percent of the respondents indicate a shift to another mode, automobile still remains the number-one preference for 60 percent of the respondents. When the congestion fee is increased to $4.00/day, an additional 10 percent shift in the number of respondents occurs in all areas surveyed.

When, in addition to the congestion fee of $2.00/day, an increase in the price of fuel to $0.40/L is introduced in the concept statement, the effect on mode shift from automobile to other modes is almost negligible. This somewhat unexpected result might be explained by the already fairly low level of automobile use when the increase in the fuel price is introduced. In order to give respondents an option to avoid the congestion fee assessed during peak hours by either arriving early to work and leaving early or arriving later and leaving later, they were asked to indicate their ranked modal preferences under a flexible-hours scheme. The results (as can be seen in Figure 6) indicate that respondents who had shifted from automobile to other modes in response to the congestion fee revert to using their automobiles for their work trips. As a result, the percentage of respondents to the work-trip survey who use their automobile increases from 40 percent when the congestion fee of $2.00 is in effect to 60 percent when flexible work hours are introduced. It is interesting to note that transit, which picks up much of the shift away from automobile, becomes less attractive when flextime is introduced. This points out that, when developing policies to increase nonmotorized use, care should be taken to avoid running counter to the positive aspects of existing policies or practices.

It is important to note that the application of an automobile fee during peak periods is only one method among many that can accomplish similar results. Other measures might involve the institution of parking restriction, tolls, even-odd license plates for every-other-day access, or license stickers (14). The latter has been successfully put into operation in Singapore (15). Under this scheme, a special sticker that costs approximately $2.00/day must be displayed during the morning rush hours within a cordoned area of downtown.

Fuel Price Increase

To determine the effect that gasoline price increases might have on shifts in modal preference, the following directions were included in the survey: "Assume that on your next trip to work all travel conditions remained the same as at present except that the price of gasoline increased to one of the price levels indicated below." Respondents were then directed to rank the specified modes (walk, automobile, bicycle or transit) from most to least preferred for each of the following price levels: $0.26, $0.40, $0.80, and $1.05 or more per liter ($1.00, $1.50, $3.00, and $4.00 or more per gallon). The results are plotted in Figure 7.

Given current income levels, the survey indicates decreased automobile use in response to increases in fuel price, both for work and shopping-personal business trips. This is true even in areas where automobile use is currently low (Austin school trips and Philadelphia work and shopping-personal business trips), although in these areas the decrease in automobile use is much less pronounced. The decrease in automobile use for work trips is lower than that for shopping-personal business trips. This was to be expected, and it indicates that a higher priority is placed on work than on nonwork, discretionary trip making. Fuel price increases have practically no effect on the distribution of trips by mode in the Philadelphia areas surveyed. Even at the very highest price level tested [$1.05 or more/L ($4.00 or more/gal)] automobile work trips in the Huntington Beach precincts still attract more than 35 percent of the trips. For shopping-personal business trips, the percentage is reduced to about 20 percent. Observe that automobile use decreases fairly rapidly as fuel price increases up to $0.53/L ($2.00/gal). After that point, the rate of decrease slows down considerably. The nonmotorized modes, on the other hand, show fairly rapid gains up to the $0.53/L price level and then taper off quite rapidly, which suggests a plateau. Further increases in the gasoline price beyond this level translate into diminishing gains for nonmotorized modes.

A great deal of caution must be exercised when examining the above results. In addition to the uncertainties associated with translating perceptions into preferences, the additional question of timing is critical when discussing demand changes in response to fuel price increases. Whereas respondents generally react to a doubling in the price of fuel by assuming that such an increase occurs instantaneously, in reality, price increases take place over a period of time, thus giving the consumer time to adjust to the small incremental increases. For this reason, elasticities of demand estimated from the above modal preferences are certain to be considerably greater than would occur under actual conditions.

CONCLUSIONS

A summary of the most important findings is given below. Table 6 provides a comparative view of the effect on modal preference of the various strategies tested. Current preference is a good indicator of current mode choice. In general, however, indicated preference levels tend to underestimate choice of auto-

Figure 6. Effect of congestion fee plus increased fuel prices.

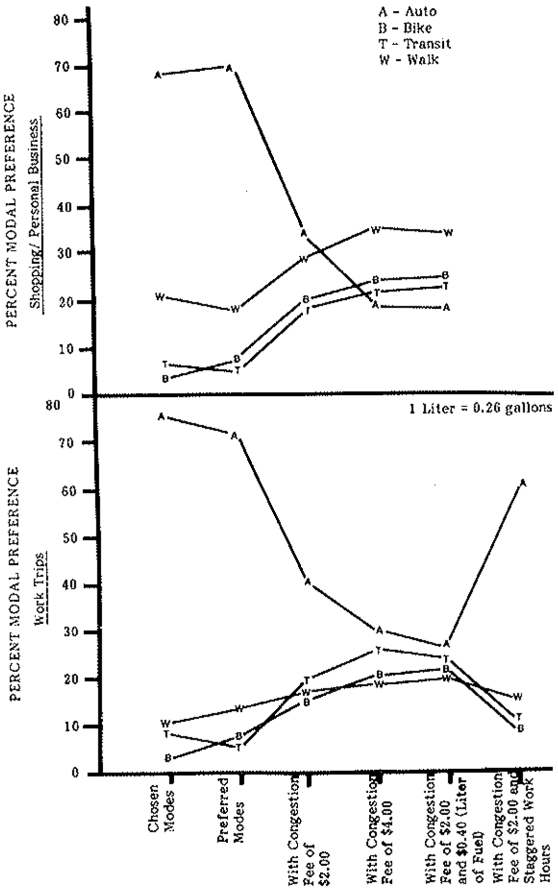
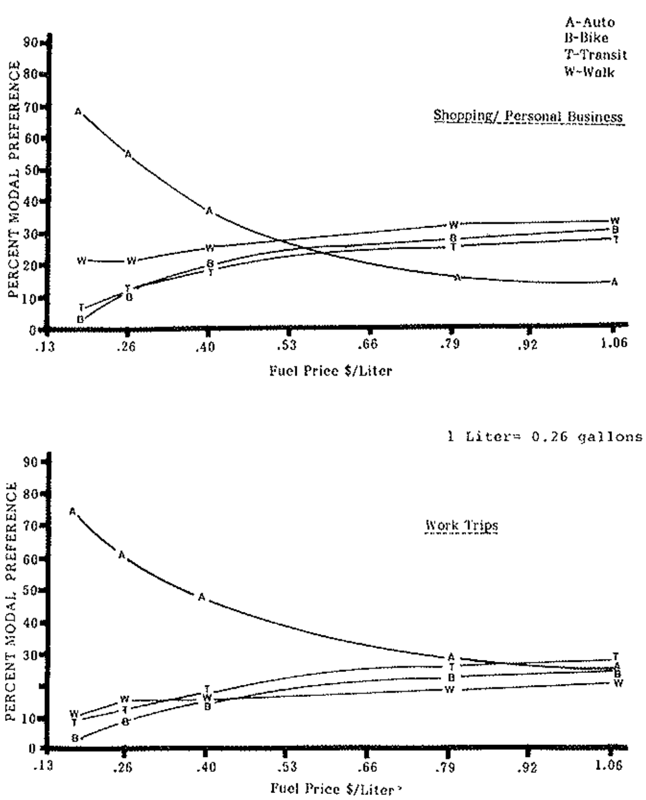


Figure 7. Mode choice versus fuel price.



mobile, transit, and walk, and overestimate actual bicycling. The following ordering shows the hierarchy of strategies, based on their potential for effecting shifts from the automobile:

1. Compact land use,
2. Congestion fee,
3. Fuel price increases,
4. Pedestrian facilities, and
5. Bicycle facilities.

The hierarchy of strategies tested for their ability to increase walking or bicycling is as follows:

1. Compact land use;
2. Pedestrian or bicycle facilities, respectively;
3. Congestion fee;
4. Fuel price increase; and
5. Bicycle or pedestrian facilities, respectively.

The concept of a compact land-use distribution (which includes walk and bicycle facilities, with work, shopping, and other opportunities within walking and bicycling distance) produces the greatest shift in preference from automobile to walking and bicycling. The relative importance of this strategy underscores the realization that the most effective way of promoting use of nonmotorized modes may not always be responsive to policy actions. This is not to say, for instance, that new economic forces such as that brought about by a limited gasoline supply, might not be able to influence how people choose their places of residence in relation to their places of employment. In such a case, gasoline supply or its cost could be set by policy.

Separate facilities play an important role in people's preference for nonmotorized modes, second only to that of compact land use. The significance of facilities is further emphasized by the fact that the compact land-use scenario contains not only the very important element of short trip distance, but also the element of separate facilities for nonmotorized travel. Thus, facilities can play a prominent role in increasing nonmotorized travel, particularly if they are provided in the context of compact land-use configurations, such as college campuses, residential areas near CBDs, and areas where shopping opportunities are within walking or bicycling distance of medium- to high-density residential areas.

Pricing, either through congestion fees or increases in fuel prices, has the potential for causing significant shifts from the automobile. However, transit absorbs a large portion of the shift, thus reducing the potential nonmotorized share. An increase in the price of fuel to $0.40/L is somewhat less effective in causing shifts from the automobile than is the application of a congestion fee of $2.00/day. It does have the effect, however, of increasing consumers' preference for transit, especially for shopping and personal business trips.

Current level of nonmotorized use appears to be related to the potential increases in walking and bicycling. Both the Austin precincts, with their relatively high current share of bicycle use, and the precincts in Philadelphia, with their high level of walking, exhibit the highest shifts toward bicycling and walking, respectively, with the introduction of facilities.

With the exception of the compact land-use scenario, the application of any strategy, by itself, causes a maximum shift of approximately 20 percent to either walking or bicycling. Given the hypothetical and somewhat unrealistic nature of the scenarios, this value can be taken to represent the upper-limit diversion from automobile to walking and bicycling (for noncompact land-use settings).

Different strategies affect modal preference differently, depending on the purpose of the trip. There is little or no difference in the preference level between the trip purposes tested under the improved pedestrian and bicycle facilities strategies. Significant differences do exist between the levels of preference for work trips and strategies. For example, work trips, which are taken usually during rush periods, are less affected by both strategies than are shopping-personal business trips. This is to be expected since the latter can be more easily scheduled for off-peak periods. In the case of the fuel pricing strategy, shopping-personal business trips can be consolidated, which thus reduces the impact of the price increase.

Current preferences are good indicators of current mode choice, but no assurances can be made at this point about the reliability of future preferences for predicting future choice. The modified preferences result from changes in the perception of the mode attributes as a result of the scenarios introduced. Whether this modified perception will lead to changes in behavior as reflected by actual shifts to other transportation modes is the subject of perception and preference modeling work just completed. Those results will be publicized at a later date.

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