HIGHWAY RESEARCH RECORD

Number 197

Passenger Transportation

6 Reports

Subject Area

15 Transportation Economics

HIGHWAY RESEARCH BOARD

DIVISION OF ENGINEERING NATIONAL RESEARCH COUNCIL
NATIONAL ACADEMY OF SCIENCES—NATIONAL ACADEMY OF ENGINEERING

Washington, D.C., 1967 Publication 1528

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Foreword

The massive problems of integrated transportation systems have brought an increasing awareness of the need to take into account both present and future economic, sociological and psychological costs and benefits. The six papers in this RECORD are directed toward understanding how the public evaluates the costs and benefits of transportation from point to point—especially in the urban environment. Although the impact of highway systems on their environment has long been recognized, consideration of the effects of alternative modes of transportation and the multiple interfaces among the modes greatly complicates the problem of analysis.

Wynn and Levinson attempt to estimate the possible use of public transit in middle-sized urban areas of 250,000 to one million people. The study postulates that presently only about 5 percent of the urban population live in what might be termed car-saturated households. If the whole urban area contains nothing but car-saturated households, there would be an increase of only about 45 percent in the number of trips generated. It appears that urban residents, in spite of travel constraints which apply in one form or another to nearly everyone, are able to achieve a large proportion of their maximum travel desire under existing conditions. The study also notes that a substantial portion of the urban population is not eligible to drive either because of age or physical restrictions. The authors believe there is a large potential among the non-drivers for a suitable form of public transportation.

Bostick and Greenhalgh studied the relationship of passenger car age to number of miles per year that the car is driven. They present empirical data on the effects of passenger car age, multicar ownership and other factors on miles traveled by automobiles. The data were gathered in home interviews in Illinois and Montana and in a nationwide automobile-use study conducted by the Bureau of the Census. Based upon 1,500 vehicles, the average annual mileage for vehicles under three years old was 11,000; for vehicles four to five years old, 9,500 miles; and older vehicles, 4,500 per year decreasing as the vehicle became older.

Hille and Martin report on the methodology being used in a study of consumer preference in transportation conducted in the Baltimore metropolitan area. The study is directed toward identifying the characteristics of an ideal transportation system as conceived by the consumer. The findings of the study will be based on an analysis of 550 personal interviews of consumer attitudes and motivations.

Recognizing that how people perceive the cost of the journey to work is far more important in determining choice of mode of transportation than the actual economic costs, Lansing and Hendricks discuss two national sample surveys in metropolitan areas in which questions were asked about the cost of the journey to work. The results of the survey showed that people are well aware of costs which must be paid in cash which are directly associated with the journey to work, such as parking fees and fares to transit companies. In estimating the cost of fuel for the journey to work by automobile most people estimated the cost too high. Most people who have estimated the cost of automobile transportation do not include depreciation costs or other costs of ownership.

Botzow presents a method for estimating auto commuting costs looking at the economic variables to be used in computing costs. He develops a method of analysis which in addition to operating speed, time value and accident potential, includes point of trip origin as a factor. The method which reflects trip origin produces total and out-of-pocket cost per car-mile and per passenger-mile as well as a trip cost for commuting by auto. An analysis is made for each of 20 counties in the New York-Northern New Jersey area. It is suggested that two out-of-pocket costs be developed, one for the five heavily populated counties at the center of the area and the other for the surrounding counties. Because county of residence affects auto commuting costs, future analyses of trans-Hudson auto commuter will use separate auto operating costs for each county or county group rather than one overall operating cost.

In a similar vein, Wachs discusses the relationships between drivers' attitudes toward alternate route choices. This study is based on home-interview studies which attempt to relate the reasons drivers cite for choosing one route for a trip rather than an alternate, to the characteristics of the drivers and to the characteristics of the alternatives. Tests are made to determine whether the importance of the various reasons differs with the type of trip being made. By using factor analysis an attempt was made to determine whether responses about different reasons for route choice are measuring the same or different underlying values. The study attempts to determine whether the socioeconomic characteristics of the people or the performance characteristics of the routes most heavily influence attitudes. A statistical analysis is used to determine how strongly these variables are interrelated.

Contents

Some Considerations in Appraising Bus Transit Potentials

F. HOUSTON WYNN and HERBERT S. LEVINSON, Wilbur Smith and Associates

•WHEN public transportation systems in all of the more than 200 urbanized areas in the United States are examined, only a few of the largest are found to have extensive private right-of-way public transport facilities. In the great majority of these communities, motor buses operating in the general traffic stream provide the basic transit services. Often, this service is limited in coverage, speed, and other performance characteristics, with bus patrons constituting only a small fraction of area-wide tripmakers.

More effective utilization of bus transit facilities would reasonably be expected to reduce the number of private vehicles which traverse major urban travel corridors, provide relief to congested conditions (extend the time when relief facilities will have to be built), and extend the useful life of existing streets and highways. Means to achieve this represent a major challenge to transportation planners. It was with this possibility in mind that the U. S. Bureau of Public Roads authorized a study to develop guidelines and procedures whereby both minimum need and maximum potential for bus transit could be ascertained for the middle-sized urban area. The following study goals were set forth:

1. To define the latent (unrealized) travel potentials of urban residents, and to consider the implications as they may apply to transportation planning;
2. To describe household characteristics and community relationships which relate to urban travel and choice of mode;
3. To develop concepts and criteria for desirable bus service;
4. To predict probable bus "ridership" related to both conventional and unconventional concepts of service and costs; and
5. To estimate potential reduction of street and highway capacity requirements by maximizing bus transit.

A principal goal of these investigations is the definition of procedures which can be used to estimate an "optimum" or "maximum" amount of travel that residents of an urbanized area are capable of making. The definition is based on population characteristics, amounts and intensities of land use, the extent and capabilities of the main alternative forms of personal transport, and the costs and special benefits associated with each.

OVERALL STUDY DESIGN

In a broad context, the development of a study framework for maximizing bus potentials must consider four basic interrelated components.

First, it is necessary to estimate the total market for urban travel; i. e., to appraise the cross-elasticity of urban travel demands. This is the trip-generation phase of the analysis. Second, having defined the potentials for urban travel, this travel must then be allocated to the different urban transport modes. This is commonly termed "trip diversion"; most current modal split analyses fall into this category. Third, and more evasive, are the land-use impacts associated with urban transport improvements. Would, for example, a radically new form of bus transport exert a centrifugal, or

Paper sponsored by Committee on Economic Forecasting and presented at the 46th Annual Meeting.

centripetal influence on urban development? Finally, the role of public policy in regard to each of the preceding factors must be evaluated.

The present paper places emphasis on the trip-generation phase of the problem, with special attention given to the latent travel potentials of urban residents.

Some Basic Dimensions

The heaviest concentrations of travel in most urbanized areas are, and will continue to be, in the corridors which serve the central business district (CBD). This does not preclude the possibility or even the likelihood that other centers of activity can develop large concentrations of demand. It seems reasonable that a transport plan designed to effectively serve travel generated by the CBD should also be readily adaptable to traffic needs in other parts of the urbanized area.

Much argument revolves about the selection of a mode and system (or combination of modes and systems) of personal transport to provide optimum service in the urbanized area. A large part of today's residential community in every urbanized area has been built to very low densities. Even the largest urbanized areas incorporate much low-density residential development. For example, over 30 percent of the dwellings within the Cordon Area of the Penn-Jersey Transportation Study (1960) were detached units averaging three structures per net residential acre. More than half of these were built during 1945 to 1960, accounting for more than 60 percent of all nonresidential units constructed in that period (1). Travel by the occupants of these areas is presently oriented toward use of the personal car. New concepts in public transport are needed if they are to be provided with effective mass transportation.

The competitive aspect of travel by automobile and bus mainly relates to travel between the CBD and the places where people live. The CBD attracts a large proportion of all public transport use within most urban areas, partly because it represents the most intensive concentration of travel demand in any community and therefore offers the best target for frequent, efficient service. Bus services in many communities are totally oriented to the city center, and there are strong interrelationships between service frequency and intensity of downtown land use.

Depending on the number of CBD approaches which serve the urbanized area, the principal corridors of travel will develop critical intensities of traffic demand under different conditions of population growth and downtown employment density. A relatively small population spread along a narrow valley bottom or hemmed in between mountains and a body of water can generate, in the few available corridors, CBD approach volumes equal to those which occur in symmetrically developed urban areas only when they have reached much greater overall size.

For example, Honolulu (population about 300, 000) occupies a very restricted site on the shore and in the foothills of the Koolau Mountains and principal traffic flows must parallel the ocean. The 1960 traffic survey found 18-hour traffic of 125, 000 vehicles per day on a screenline northwest of CBD and 144, 000 vehicles in the corridor southeast of the center. Parallel express highways have been built which provide two large-capacity routes for the flow of traffic in each corridor. In contrast, a large, symmmetrical urban area, such as Washington (population 1, 569, 000 at time of 1956 survey) has developed about a dozen traffic service areas radial to the CBD in which corridors of heaviest demand develop traffic volumes somewhat less (1956 data) than the two principal corridors in Honolulu.

Typical examples of peak-hour traffic on the approaches to the CBD in medium-sized cities are shown in Figure 1. These examples, detailed in Table 1, were derived from analyses of CBD cordon counts and origin-destination data obtained from many sources (2). Figure 2 shows the relationship between travel mode and city size at the CBD cordon.

These models assume that one-fourth to one-sixth of the total CBD cordon crossings use the principal corridors. In some cities, individual corridors might actually accommodate a larger proportion of the daily CBD travel, particularly where cities front a body of water.

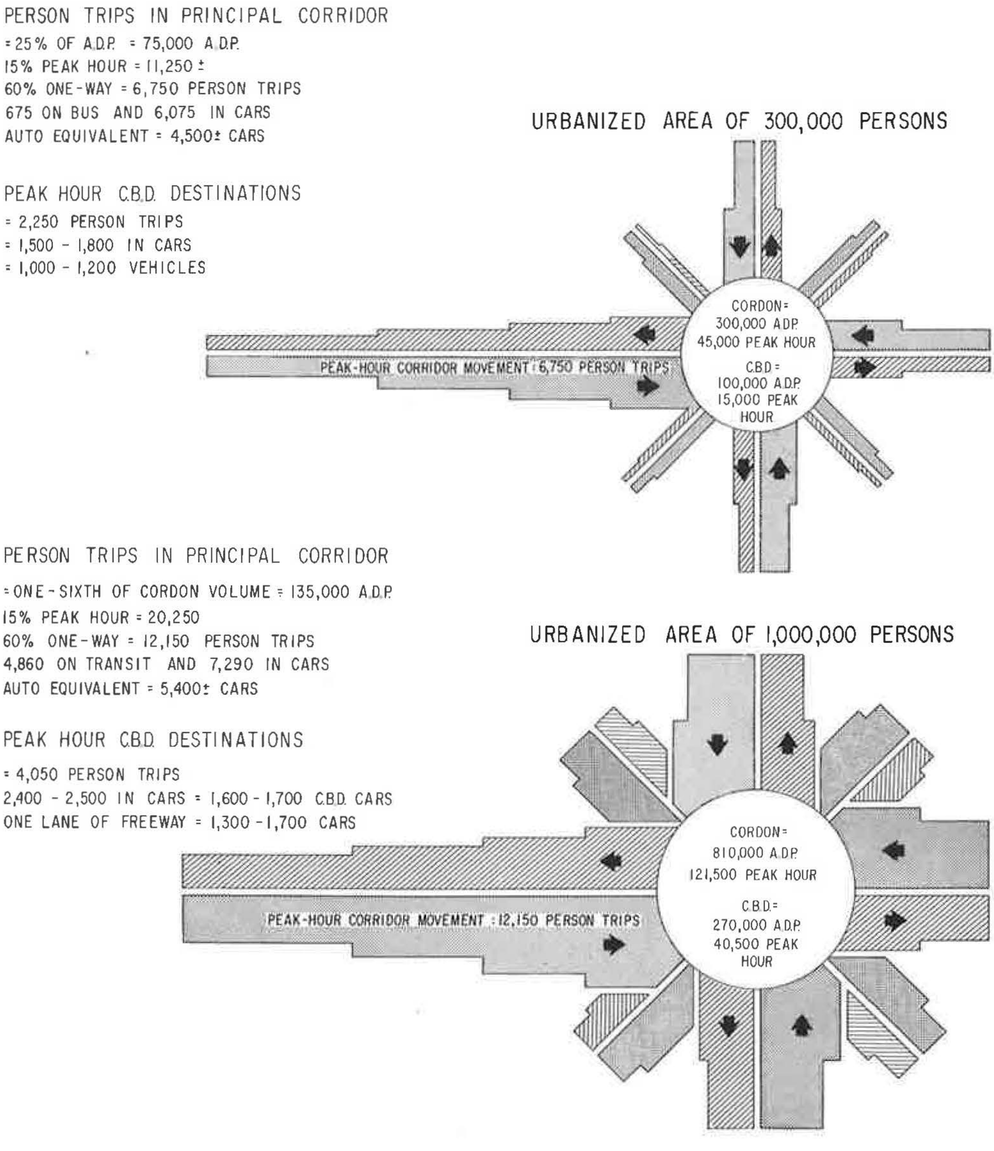


Figure 1. Peak-hour directional traffic flows in principal corridors—middle-sized urban areas.

In the first example, it is assumed that the CBD generates about 100,000 trips, origins and destinations, each day (see Fig. 1 and Table 1). If the urbanized area is symmetrically developed, the corridors of most intensive use would accommodate about 25 percent of the total volume (i.e., 25,000 trips). About 15 percent of these trips would occur in the peak hour (3,750 trips). Trips generated in the CBD represent only about one-third of all peak-hour corridor traffic at the CBD cordon (the remainder are through trips), so that the total corridor volume at peak hour would amount to about 11,250 person trips. About 60 percent, or 6,750, would constitute the traffic flow in the heaviest direction of travel. Of this flow, about 10 percent are person trips in transit, as shown for areas with "centralized" CBD in Figure 2. The remainder, at 1.5 persons per car, would require some 4,050 private vehicles. Cars used by residents of the urbanized areas average about 1.5 persons per trip, overall, according to

TABLE 1

PEAK-HOUR TRAVEL DEMAND IN HEAVILY TRAVELED CORRIDORS ON APPROACH TO CENTRALIZED CBD

Item	Typical Centralized CBDs		
Urban area population	300, 000	500, 000	1, 000, 000
Daily person trips generated in CBD	100, 000	160, 000	270, 000
Percent in heaviest corridor	25	20	17
Number in heaviest corridor	25, 000	32, 000	45, 000
Peak hour = 15 percent	3, 750	4, 800	6, 750
Corridor = 3 × CBD peak	11, 250	14, 400	20, 250
One-way person trips (60 percent)	6, 750	8, 640	12, 150
Percent ride transit	10	25	40
Number ride transit	675	2, 160	4, 860
Number in cars	6, 075	6, 480	7, 290
Number cars at 1. 5 occupancy	4, 050	4, 320	4, 860
Total one-way vehicles[a]	4, 500	4, 800	5, 400

[a]Trucks and buses in heavy direction of flow at peak hour assumed to constitute an "auto-equivalent" equal to 10 percent of all vehicles in traffic. (Trucks and buses have an effect on traffic capacity equal to two or more times the same number of cars (5).)

published data. These cars, plus trucks and buses, increase the "auto-equivalent" one-way flow of vehicles to about 4, 500 peak-hour corridor volume.

In the typical urban complex of one million persons (see Fig. 1, also third example in Table 1), the CBD would generate about 270, 000 daily person movements. In a symmetrical environment, the corridor of heaviest travel would have to accommodate about one-sixth of the cordon volume, or 45, 000 person trips. Peak-hour travel would consist of about 6, 750 CBD trips plus 13, 500 through trips at the cordon, with approximately 60 percent in one direction, for a total of about 12, 150 one-way person trips. Under present conditions, about 40 percent of these trips would be expected to use transit across the cordon of a centralized CBD. This would leave 7, 290 persons in 4, 860 cars in the heaviest direction of flow at the CBD cordon. With adjustment for trucks and buses, the auto-equivalent one-way volume would amount to about 5, 400 cars.

Alternatively, in a "decentralized" CBD only about 25 percent of the 12, 150 one-way person trips would be expected to use transit, leaving about 9, 100 persons in 6,100 cars in the heaviest direction of flow at the CBD cordon. With adjustment for trucks and buses, the auto-equivalent volumes of vehicular traffic would be approximately 6, 800 cars.

Assuming that corridor volumes at the CBD cordon had reached levels (or would soon do so) which, in a car-oriented city, would require major new improvements—extensive street widening, construction of a freeway, or additional lanes on existing freeways—what conditions would have to be met in the design of a bus system to entice a sufficiently large voluntary diversion of car riders to transit so as to defer or supplant the need for this improvement?

A modern 6-lane freeway, designed for heavy central-area traffic in an urbanized area under half-a-million people, would handle 4, 000 to 4, 500 vehicles (passenger car "equivalents") in the direction of heaviest flow at the peak hour. A 4-lane freeway, designed for similar conditions, would provide efficient service for 2, 800 to 3, 000 vehicles (car-equivalents). The difference (1, 200 to 1, 500 vehicles or 1, 800 to 2, 250

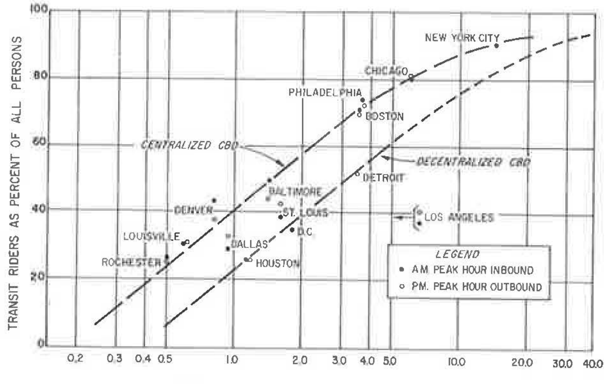


Figure 2. Transit riders as percent of persons entering or leaving central business district at peak hours (typical weekdays).

TABLE 2

TRANSIT TRIPS AT CBD CORDON: ONE-WAY PEAK HOUR AS PERCENT OF DAILY TWO-WAY TRIPS
(Typical Weekday, Selected Urban Areas)

Urbanized Area			Transit Trips at Cordon (thousands)		
Central City	1960 Population (thousands)	Year of Count	Peak Hour (one-way)	All Day (two-way)	Percent Peak Hour
New York City	14, 115	1960[a]	762	4, 790	15. 9
Los Angeles	6, 489	1957[b]	49	344	14. 2
Chicago	5, 959	1961[b]	180	1, 018	17. 7
Philadelphia	3, 635	1955[b]	127	948	13. 4
Boston	3, 584[c]	1954[b]	105	674	15. 6
Detroit	3, 538	1956[b]	34	304	11. 2
St. Louis	1, 608	1957[b]	26	184	14. 1
Baltimore	1, 419	1955[b]	29	238	12. 4
Houston	1, 140	1953[b]	16	146	11. 0
Dallas	932	1958[b]	21	144	14. 6
Denver	804	1962[a]	13	64	20. 3
Louisville	607	1957[b]	15	118	12. 7

[a]Morning peak hour.
[b]Evening peak hour.
[c]Population of 152-town Boston region, 1962.
[d]Transit riders entering CBD at cordon have been doubled to develop two-directional flows.

Note: Definition of CBD varies, determined locally by persons in charge of cordon count survey.

person trips) represents the magnitude of travel which, if diverted from car to transit, would provide substantial relief to the highway construction program by enabling the designer to scale down a projected freeway from 6 to 4 lanes.

For a larger urbanized area, the design capacity relationships are slightly modified. The difference between a 4- and 6-lane facility approximates 1, 500 to 1, 600 vehicles (2, 250 to 2, 400 person trips), again representing the substantial relief required to achieve a practical saving in new freeway construction (one lane each way).

Peak-hour one-way transit rides at the CBD cordon represent 10 to 20 percent of the two-way daily transit movement entering and leaving that area, averaging about 12. 5 percent in urban areas under two million persons (Table 2). If transit service is improved sufficiently to achieve the substantial relief by attracting riders away from private cars, diversion on a daily basis in the particular corridor under study would range from about 14, 000 to 20, 000 riders in urban areas under a million persons.

These values assume that transit service improvements adequate for peak-hour diversion would attract the same proportion of riders away from cars at all hours of the day. It might, of course, prove more feasible to divert riders to transit on a selective basis, concentrating on peak hours and the principal purposes of travel at those hours.

In the larger cities, the potential savings on freeway construction or on other new highways are significant, provided that bus operations of a practical nature can be devised which will achieve the levels of performance needed to divert travel. This is especially true in asymmetrical cities, where a few corridors must serve the vast bulk of centrally oriented travel. The advantage of high-volume transit riding is presently realized in cities such as Philadelphia, Washington, and New Orleans, where buses carry more than 50 percent of all peak-hour person movements on selected streets (for example, Connecticut Avenue in Washington). Bus services are also important in serving the 15-min peaks within the rush hour, or in helping reduce the duration of the peak period.

In smaller communities, the bus travel volumes required for effective freeway reduction would represent virtually the entire corridor traffic flow. In these situations the potentials for highway relief generally must be thought of in terms of special situations—restricted sites with heavier-than-average corridor volumes, or smaller scale savings, such as relief equivalent to (or taking the place of) street widening, grade separations, etc.

Mobility and Trip Generation

The potentials for bus transit may also be viewed in another context. Perhaps the goal should be to optimize mobility rather than increase capacity. This suggests that

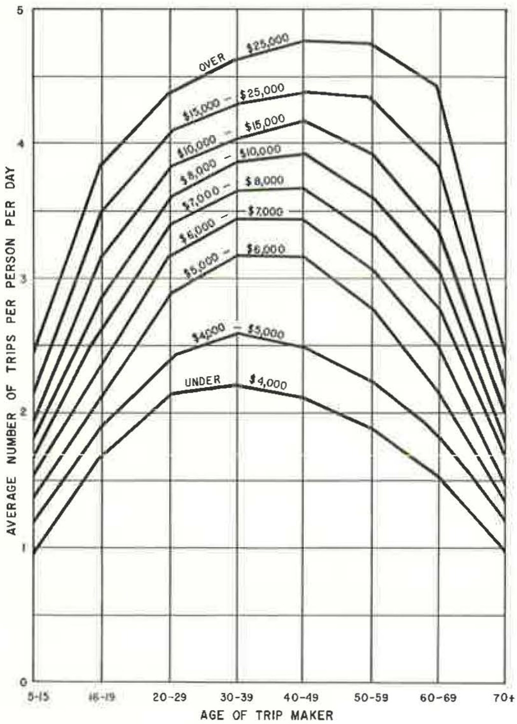


Figure 3. Trip rates related to age and household income of trip-makers (Springfield urbanized area, 1964-65).

the latent travel demands—trips not now being made—constitute a source of additional bus riders.

Research has centered on cross-sectional analysis of trip behavior in four middle-sized communities and one larger metropolitan area. These communities and their cordon area populations at time of the field surveys were: (a) Baltimore, Maryland, 1, 600, 000 population; (b) Springfield, Massachusetts, 531, 000 population; (c) Richmond, Virginia, 418, 000 population; (d) Allentown-Bethlehem-Easton (Lehigh Valley), Pennsylvania, 345, 000 population; and (e) Columbia, South Carolina, 200, 000 population.

Current trip-estimating techniques are usually designed to predict the numbers of trips that resident populations are likely to make under conditions similar to those that presently exist. These are almost always stratified to some degree (according to the trip-maker's purpose or income). The present analyses attempt to estimate the number of trips people might make, if constraints to travel were minimized or eliminated. It is recognized that the desire to make a trip for a certain activity, the selection of a particular activity center for the trip destination, and the choice of mode to be used are all parts of one decision-making process. The wish to make a trip is modified by a host of circumstances before it becomes a decision to make a trip. In appraising the alternatives, the trip-maker is constrained by the amount of time-loss he is willing to accept in traveling to and from a given activity, the out-of-pocket costs of his trip, and the availability of facilities for travel. His appraisal of each factor will relate directly to the urgency of his motive.

Age and Income Variables—The age and income of trip-makers have important bearing on the number of trips they perform. These interrelationships for Springfield, a typical urban area, are shown in Figure 3, and are summarized in Tables 3 and 4.

The average number of daily trips, regardless of age, was found to increase from less than 1. 6 per person at lowest family income to more than 3. 6 trips per day at the highest. The effects of age show a different, but equally consistent story. Travel increases from 1. 5 daily trips at ages 5 to 9 years to nearly 3. 6 trips at ages 40 to 49, then declines to about 1. 3 trips for persons 70 and older. Within the matrix of Table 4, the pattern is nearly as consistent for each age grouping and income class as for the overall totals. Some discrepancies show up, but these may relate to differences in household size (number of persons in each dwelling unit).

Eligibility to drive affects trip-making in many households, particularly as it relates to age. About 31 percent of the Springfield area population is too young to drive, including about 10 percent under 5 years of age; another 8 percent is 16 to 19 years of age (old enough to drive) and, for the most part, still living at home; 13. 4 percent is over 60 years of age (with more than two-fifths of the people in this stratum over 70 years old).

The age distribution of trip-makers provides insight into living patterns in the middle-sized cities. More than 45 percent of persons in the lowest income households are over 60 years of age. Most of these are no longer employed. The combination of old age, low income, and no jobs has resulted in very low rates of trip production,

TABLE 3

NUMBER OF PERSONS BY GROSS HOUSEHOLD INCOME AND AGE[a]
(Springfield, Urbanized Area, 1964-65)

Age (years)	Annual Household Income ($)									
	Under 4,000	4,000-5,000	5,000-6,000	6,000-7,000	7,000-8,000	8,000-10,000	10,000-15,000	15,000-25,000	Over 25,000	All Persons
5-9	4,108	4,690	7,604	8,311	7,024	6,224	4,723	1,540	402	44,626
10-15	4,555	4,024	7,415	7,171	7,264	8,057	6,250	2,134	624	47,494
16-19	3,869	2,906	3,745	4,325	3,932	4,500	4,558	1,952	134	29,921
20-24	2,335	2,959	3,802	2,956	2,240	2,951	2,693	931	25	20,892
25-29	1,604	2,829	4,066	4,056	2,805	2,536	1,976	484	14	20,370
30-39	3,542	5,241	9,496	8,635	7,885	7,997	6,077	1,712	688	51,273
40-49	4,182	4,817	7,657	8,127	8,550	9,353	10,106	3,910	392	57,094
50-59	5,827	5,020	6,364	5,925	4,868	5,855	6,049	2,797	574	43,279
60-69	11,993	5,341	3,936	2,821	2,422	2,163	1,522	627	474	31,299
70+	13,740	3,635	1,793	1,612	863	862	1,028	341	238	24,112
All ages	55,755	41,462	55,878	53,939	47,853	50,498	44,982	16,428	3,565	370,360

[a]This table contains data only on those persons who occupy households which reported annual income (about three-fourths of all interviewed households).

particularly by persons over 70. Nearly half (46. 5 percent) of all persons over 60 years of age in the study area are in the lowest income group.

At higher income levels, the very old (over 70 years) perform a substantial amount of travel, those from households with incomes over $7, 000 averaging slightly more than 2 trips a day, or about twice as much travel as those with very low incomes. This implies that the lower income elderly may be constrained by lack of funds, although it is not clear whether such constraint might relate to their inability to pay for travel, or lack of money to purchase goods and services at the points of activity which attract travel.

At the other end of the age scale, children and adolescents (ages 5 to 19) are a substantial proportion of the persons who occupy the lowest income households. Some of these, of course, are dependents of underprivileged and/or unskilled parents, abandoned mothers, and broken homes. The trips performed by these young people reflect the incomes and travel patterns of their parents. In general, the adult population, ages 20 to 60, constitutes the parent group to whose households the dependent children's income classifications are related.

Travel by young people increases with rising family income, much like the patterns recorded for elderly persons. Within the dependent groups there are distinct differences which relate to the pecularities of each age. It may be inferred that most of the travel by persons under 10 years of age is made in company with adults; some of this travel is incidential to the parent's motive, although many of the parents' trips are

TABLE 4

TRIPS PER PERSON (ALL MODES) BY GROSS HOUSEHOLD INCOME[a] AND AGE
(Springfield Urbanized Area, 1964-65)

Age (years)	Annual Household Income ($)									
	Under 4,000	4,000-5,000	5,000-6,000	6,000-7,000	7,000-8,000	8,000-10,000	10,000-15,000	15,000-25,000	Over 25,000	All Incomes
5-9	1.06	1.31	1.39	1.30	1.51	1.76	1.90	2.10	2.21	1.49
10-15	0.87	1.20	1.59	1.59	1.85	1.81	1.94	2.28	3.16	1.67
16-19	1.71	1.92	1.87	2.38	2.79	2.90	3.40	3.55	3.10	2.62
20-24	2.41	3.02	3.21	2.96	3.30	4.82	3.87	3.03	–	3.38
25-29	2.85	2.20	3.22	3.42	3.47	3.83	4.67	3.50	–	3.35
30-39	2.24	2.59	3.20	3.82	3.89	3.90	3.92	4.21	4.63	3.53
40-49	1.91	2.39	3.18	3.30	3.70	4.40	4.24	4.39	3.54	3.58
50-59	1.93	2.25	3.11	2.76	3.09	3.92	3.76	3.69	4.82	3.06
60-69	1.80	2.01	1.85	2.45	2.81	3.06	3.27	4.56	2.90	2.27
70+	1.04	1.28	1.75	1.82	2.34	1.76	1.96	2.37	1.65	1.32
All ages	1.58	2.02	2.57	2.62	2.89	3.28	3.40	3.52	3.61	2.66

[a]Trips per capita for persons living in households with the designated level of income.

Note: Tables 3 and 4 contain data only on persons and trips from households for which income data were reported (about three-fourths of all households interviewed).

TABLE 5

DAILY TRIPS PER HOUSEHOLD RELATED TO CARS OWNED, NUMBER EMPLOYED, INCOME
(Springfield, Massachusetts, 1964-65)

Cars Owned	Persons Employed		Annual Income ($) Under 4,000	4,000-5,000	5,000-6,000	6,000-7,000	7,000-8,000	8,000-10,000	10,000-15,000	15,000-25,000	Over 25,000
0	0	Trips	15,135	2,220	140	95	—	100	25	—	—
		Households	12,520	1,590	115	70	—	35	25	—	—
		T/H	1.21	1.40	—	—	—	—	—	—	—
0	1	Trips	10,535	6,800	2,635	1,560	335	310	—	105	—
		Households	4,905	2,215	900	630	190	70	—	15	—
		T/H	2.15	3.07	2.93	2.48	—	—	—	—	—
0	2+	Trips	345	1,275	1,225	1,635	940	105	990	—	—
		Households	80	295	390	400	255	25	110	—	—
		T/H	—	4.33	3.14	4.08	3.68	—	—	—	—
All 0		Trips	26,015	10,295	4,000	3,290	1,275	515	1,015	105	—
		Households	17,505	4,100	1,405	1,100	445	130	135	15	—
		T/H	1.49	2.51	2.85	2.99	2.87	—	—	—	—
1	0	Trips	27,065	7,930	5,385	1,515	700	770	310	185	285
		Households	6,255	1,580	790	285	65	80	125	50	85
		T/H	4.30	5.02	6.82	5.32	—	—	—	—	—
1	1	Trips	27,400	47,060	84,880	68,875	52,384	44,300	28,710	8,630	2,150
		Households	4,400	7,980	10,970	8,615	5,780	4,470	3,055	790	210
		T/H	6.23	5.90	7.73	8.00	9.05	9.93	9.40	10.90	10.20
1	2+	Trips	3,380	10,690	21,035	33,620	37,230	50,315	31,525	7,605	270
		Households	420	1,120	2,410	3,400	3,505	4,650	2,680	715	40
		T/H	8.05	9.53	8.74	9.90	10.30	10.82	11.75	10.65	—
All 1		Trips	57,845	65,680	111,300	104,010	90,314	95,385	60,545	16,420	2,705
		Households	11,075	10,680	14,170	12,300	9,350	9,200	5,860	1,555	335
		T/H	5.22	6.15	7.86	8.45	9.66	10.36	10.31	10.55	8.07
2+	0	Trips	1,355	340	710	—	—	—	415	190	—
		Households	180	95	65	—	—	—	50	30	—
		T/H	7.53	—	—	—	—	—	—	—	—
2+	1	Trips	2,430	3,730	13,100	16,620	19,670	24,575	26,845	14,730	7,380
		Households	305	480	1,355	1,355	1,570	1,685	2,030	1,065	560
		T/H	7.98	7.78	9.68	12.26	12.55	14.55	13.20	13.82	13.17
2+	2+	Trips	2,030	2,705	14,745	16,795	26,085	44,650	63,730	26,065	2,900
		Households	165	270	1,285	1,520	2,205	3,470	4,655	1,830	215
		T/H	—	10.00	11.50	11.05	11.80	12.87	13.70	14.25	—
All 2+		Trips	5,815	6,775	28,555	33,415	45,755	69,225	90,990	40,985	10,280
		Households	650	845	2,705	2,875	3,775	5,155	6,735	2,925	775
		T/H	8.95	8.02	10.55	11.60	12.10	13.42	13.50	14.00	13.25

made to accommodate needs of the child. Much the same can be said about 10-to-15-year-olds, although they are shown to average slightly higher rates of travel. The upper-teen group is distinctly more mobile, generating trips at rates which exceed those of the younger dependents by 50 percent or more.

Highest rates of travel are performed by the adult population (family heads and workers) between the ages of 20 and 60. Their lowest trip rates are about twice as high as those of children and teenagers on the one hand and the senior citizens on the other hand. They maintain something like this differential at each level of income, with trip rates by upper income residents nearly twice as high as rates at the low end of the income scale. Work travel accounts for a very high proportion of trips at low incomes and is a substantial part of travel at higher incomes.

Car Ownership and Employment Variables—The age-income-trip-making patterns are further modified by differences in car ownership, and the presence or absence of employed persons in households. Accordingly, Table 5 gives data on how these variables affect trip production in households with different incomes.

Nearly a fifth of all households in the Springfield area did not have cars. These households generated less than 4.8 percent of the trips made by the area's residents. About 60 percent of all dwelling units in the Springfield urbanized area had one car, and more than 61 percent of the trips in the area (all modes) were made by persons in this group. The remaining 21 percent of all occupied units were each provided with two or more cars, and they accounted for more than a third of all the trips made by area residents.

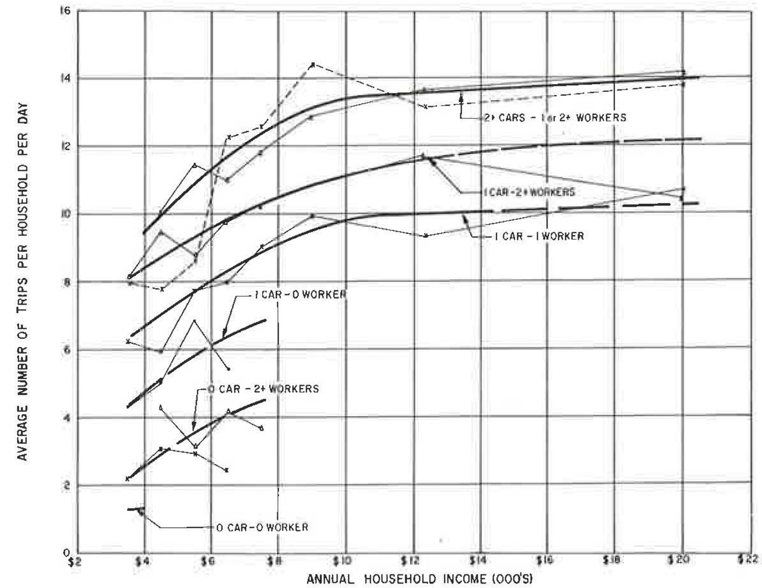


Figure 4. Daily trips per households vs workers, cars owned and income (Springfield urbanized area, 1964-65).

Trip generation in households which had one car ranged from about 4.3 trips per day, where no one was employed, to nearly 12 trips, on the average, where two or more persons worked outside the home. Very low incomes typified homes without workers, and the highest incomes were reported for households supported by one or more workers.

The pattern was the same for two-car dwellings, except that there were virtually no homes in this class without at least one working member. The majority of all two-car households were supported by one or more employed persons, and the two-worker dwellings dominated the upper end of the income scale. Average daily trip production exceeded 14 in high-income, two-worker households.

The stratification of household trip generation according to income, employment and car ownership is shown in Figure 4. (This figure has been prepared by plotting the average household trip rates listed in Table 5. Freehand curves have been fitted to the various sets of data according to number of cars and number of workers in the households.) Again, it is apparent that large increments of trip generation are associated with each of the cars in a household. At all levels of car availability, trip production rates are modified by the number of workers in the household. Size of household is not taken into account here, but households must consist of two or more adults to make use of two or more cars or have more than one worker.

Data for one-car families are the most stable, because nearly 60 percent of all households reporting their incomes fall in this category. Trip generation is shown to increase steadily with rising income in all classes under $10,000, and to level off above that value. Households without cars show distinct differences in the trip-generating characteristics of those without workers and those with one or more workers. A curve which generally fits the slope for two-car households has been fitted to data for families with one or more workers. Very few households with two workers are without cars; similarly, hardly any families with two cars are without workers.

Family Composition—At any level of household employment, car ownership, and income, the number of household occupants influences the number of trips that the household can be expected to produce. In general, per capita trip production declines with each increase in family size. Although the aggregate number of trips generated by each household increases as households get larger, the rate of increase generally slows down.

TABLE 6

OVERALL TRIP GENERATION RATES
(Springfield Urbanized Area, 1964-65)

Household Size	Number of Workers	Cars in Household 0	1	2+	Remarks
(a) Trips Per Person Per Day (All Modes)					
1 person	0	0.80	3.00	–	Average per capita trips in one- and two-person households.
	1	1.50	3.75	–	
2 persons	0	0.50	2.25	2.50	
	1	1.00	2.75	4.00	
	2	1.50	3.75	4.00	
3 persons	0	+0.80	+1.50	+1.50	Increments of travel by each person in excess of two, as indicated by household size. Add to travel by both members of two-person families to develop household rates.
	1	+1.40	+1.50	+2.00	
	2+	+1.40	+1.50	+2.00	
4 persons	0	+0.80	+1.50	+1.50	
	1	+1.00	+1.50	+2.00	
	2+	+1.00	+1.50	+2.00	
5+ persons (based on average of 6 persons in 5+ households)	0	+0.80	+1.50	+1.50	
	1	+0.60	+1.50	+2.00	
	2+	+0.60	+1.50	+2.00	
(b) Trips Per Household Per Day (All Modes)					
1 person	0	0.80	3.00	–	
	1	1.50	3.75	–	
2 persons	0	1.00	4.50	8.00	
	1	2.00	5.50	8.00	
	2	3.00	7.50	8.00	
3 persons	0	1.80	6.00	6.50	
	1	3.40	7.00	10.00	
	2+	4.40	9.00	10.00	
4 persons	0	2.60	7.50	8.00	
	1	4.00	8.50	12.00	
	2+	5.00	10.50	12.00	
5+ persons (based on average of 6 persons)	0	4.20	10.50	11.00	
	1	4.40	11.50	16.00	
	2+	5.40	13.50	16.00	

Typical stratifications of per capita trip-making by size of household, number of workers and car ownership are shown in Table 6 and Figure 5. (Appendix A contains the data on which these exhibits were based.) It is apparent that, for every given family size and number of workers, an increase in car ownership results in increased trip generation.

OPTIMUM AND MAXIMUM TRIP GENERATION IN URBANIZED AREAS

The foregoing empirical investigation reaffirms many previous findings. Numerous studies of urban travel have indicated that residents without cars make fewer trips than those who have cars and that the travel generated by the average household increases when the household acquires a second (or third) car. These relationships are interesting for another reason: they provide a basis for estimating an optimum amount of mobility within the urban area. They indicate that there are various degrees of mobility within the urban environment. Those persons who have the exclusive use of a car seem to have achieved the maximum level of mobility, those without cars have the least.

Examination of "car-saturated" households—those with as many cars as members—shows a wide variation in trip generation; however, it is to be expected that maximum mobility would vary from person to person in a given population. Some persons and households need to make more trips than others, depending on the number of persons in the household, the number who work outside the household, the level of income on which the household subsists, the ages of the residents, and possibly such environmental factors as residential densities (persons per acre) and proximity to non-home activity centers (work, shopping, recreation, school, etc.).

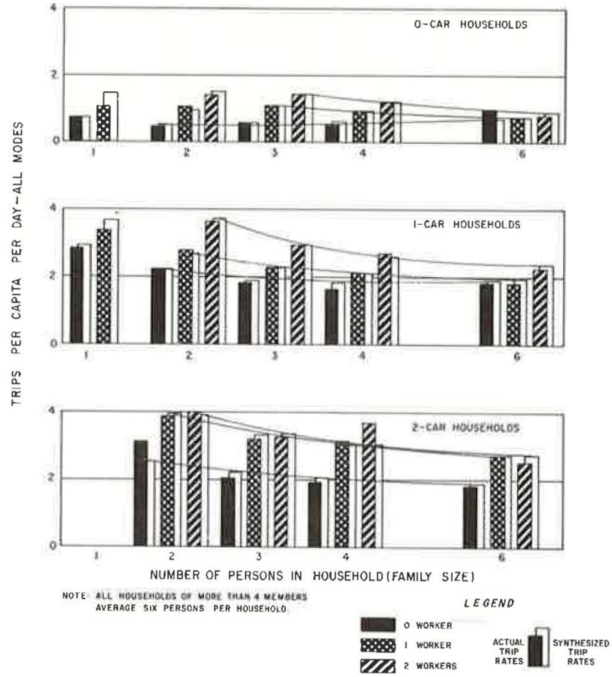


Figure 5. Urban trip generation related to family size, number of workers, number of cars owned (Springfield urbanized area, 1964-65).

The Basic Concept

Car ownership related to family size, employment and income characteristics provides a means of estimating the optimum and maximum rates of trip generation by the residents of households within an urban area.

Optimum Trips—The average trip rate computed for households with a specified number of workers and a saturated level of car ownership might be said to represent an optimum level of trip production in a community as it now exists. These people perform more trips than are generated in households without as many cars; in other words, they have the highest degree of mobility that contemporary standards can provide.

Maximum Trips—The maximum trip rates for any stratum of the mentioned population are found among those who experience no income constraints.

These definitions provide a framework for establishing ceilings on urban trip production, based on the behavior of car-saturated adults. In this regard, it is interesting to speculate on how much more travel would take place throughout a typical urbanized area if all residents were provided with an optimum degree of mobility equal to that achieved in car-saturated households. Such a computation might be regarded as a trip production ceiling, and would be useful in developing better appreciation of present mobility and its deficiencies.

It might further be postulated that this optimum level of trip production could only take place if the households were provided with a level of mobility equivalent to that of car-saturated households. Conceivably, public transport, if able to accommodate the urban citizenry at the same speed, comfort, availability, privacy, etc., afforded by the car, would generate travel at similar rates from persons who are not presently eligible to drive a car.

The conditions for optimum trip generation as defined herein do not incorporate an income variable, but relate to trip averages for households within all strata designated by family size and number of workers. Thus, a second intriguing question arises. How much travel would people perform under the conditions of maximum mobility if income

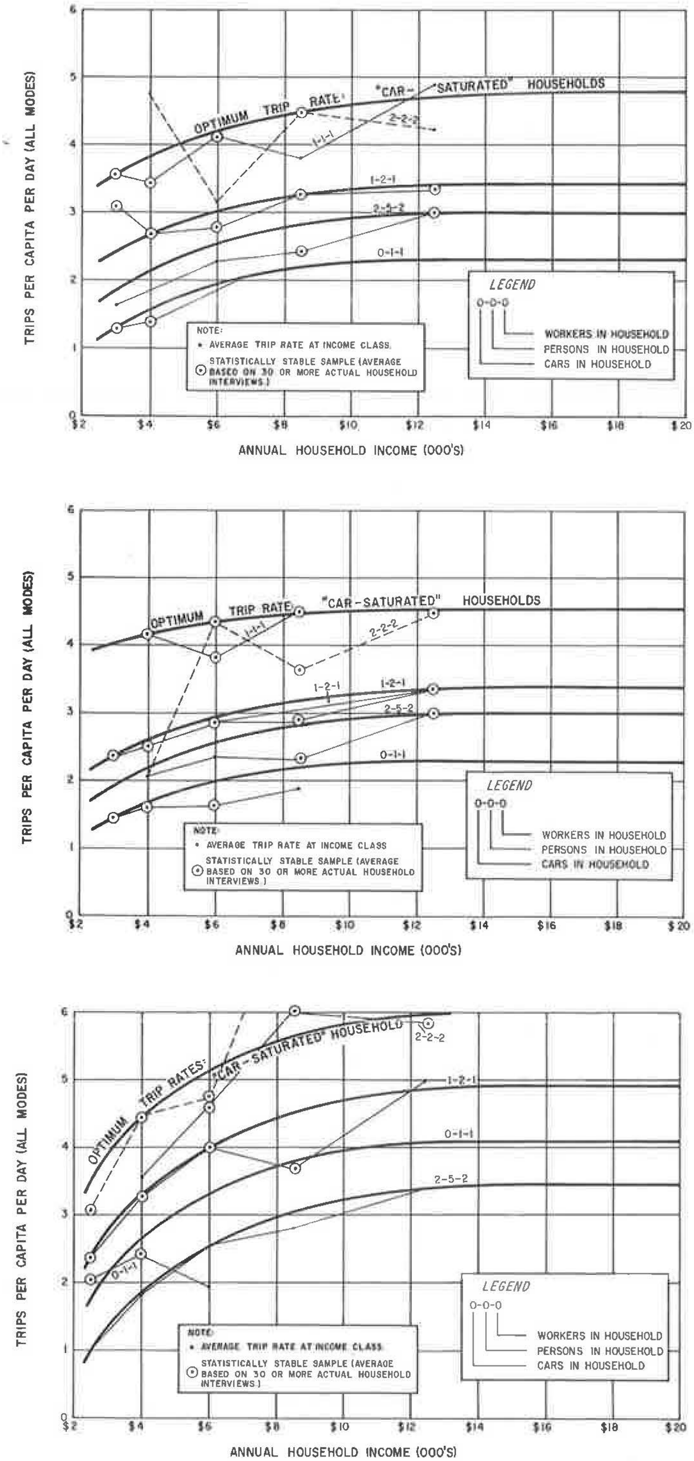


Figure 6. Trips per capita by family size, income, number employed, cars owned: (a) Springfield urbanized area, 1964-65; (b) Richmond urbanized area, 1964-65; and (c) Columbia urbanized area, 1964-65.

TABLE 7

OPTIMUM AND MAXIMUM[a] TRIP GENERATION RATES PER HOUSEHOLD
(Four Urbanized Area Surveys)

Persons in Household	Workers in Household	Baltimore Area[b] Optimum	Springfield Area Optimum	Springfield Area Maximum	Richmond Area Optimum	Richmond Area Maximum	Columbia Area Optimum	Columbia Area Maximum
1	0	2.0	3.0	3.65	3.0	4.0	3.0	4.0
1	1	3.0	4.0	5.2	4.0	6.0	5.0	6.0
2	0	4.0	6.0	7.0	6.0	6.0	8.0	9.0
2	1	6.0	9.0	8.25	7.0	7.75	9.0	10.5
2	2	6.5	8.5	9.5	8.0	9.0	10.0	12.0
3	0	6.0	6.5	8.0	9.0	10.0	12.0	14.0
3	1	8.0	10.0	11.0	10.5	11.25	12.75	15.5
3	2	8.5	10.0	11.2	11.0	11.5	13.5	16.0
3	3	9.0	—	—	12.0	12.25	15.0	16.5
4	0	6.0	8.3	8.3	11.5	13.5	15.0	16.0
4	1	9.0	12.3	13.0	13.5	14.25	16.75	18.0
4	2	9.5	14.7	15.8	14.0	14.5	17.5	19.0
4	3	10.0	—	—	16.0	17.0	19.0	19.5
4	4	10.5	—	—	—	—	—	—
5	0	8.0	12.5	12.5	14.0	15.0	16.0	17.0
5	1	11.0	16.0	17.5	16.5	16.7	20.75	22.0
5	2	11.5	17.0	18.0	17.5	18.0	21.5	22.0
5	3	12.0	—	—	18.0	18.5	23.0	24.0
5	4	12.5	—	—	—	—	—	—
5	5+	13.5	—	—	—	—	—	—
6	0	—	—	—	15.0	16.0	22.0	22.0
6	1	—	—	—	18.0	19.0	24.75	25.5
6	2	—	—	—	20.0	21.0	25.5	26.5
6	3+	—	—	—	24.0	25.0	27.0	28.5
7	0	—	—	—	17.75	18.5	—	—
7	1	—	—	—	20.5	21.0	—	—
7	2	—	—	—	25.5	26.0	—	—
7	3+	—	—	—	32.0	33.0	—	—

[a]Optimum trip generation rates were taken from the original data tabulations, rather than the "smoothed" matrix shown in Table 6. Maximum trip generation rates relate to travel by the upper-income households in each stratum.
[b]Detailed estimates of maximum trips not made for Baltimore, since income data were not collected in the O-D Survey.

limitations did not inhibit trip-making? Stated another way, how much travel would be made in today's city if every household had purchasing power equal to those whose residents presently generate the most trips? This is not an entirely irrelevant consideration, because average purchasing power, and purchasing ability within the lower economic strata of the urban population, has grown rapidly in recent years.

Accordingly, optimum and maximum rates of trip generation have been computed for the Baltimore, Springfield, Richmond, and Columbia urbanized areas and provide insight into these questions. These trip rates are shown in Figure 6 and given in Table 7. The data are stratified by household according to size, number of workers, number of cars owned, and income. Maximum trip rates are shown for households earning over $10,000 per year. These rates are substantially higher than the optimum averages for households without regard to income, which points up the significance of an adequate income in maximizing the mobility of people who have cars. Thus, the asymptotes in Figure 6 serve as a ceiling, incorporating the equivalents of both car saturation and high purchasing power.

TABLE 8

OPTIMUM AND MAXIMUM TRIP GENERATION WITH FULL POPULATION MOBILITY: YEAR OF STUDY
(Four Urbanized Area Surveys)

Item	Baltimore	Springfield	Richmond	Columbia
Population	1,608,000	531,000	418,000	196,000
Reported trips	2,675,452	1,200,016	972,958	580,721
Optimum trips	3,603,000	1,561,000	1,386,000	811,000
Maximum trips	3,963,300	1,755,100	1,485,700	901,200
Reported trips/person	1.66	2.26	2.33	2.96
Optimum trips/person	2.24	2.94	3.32	4.14
Maximum trips/person	2.47[a]	3.30	3.55	4.60
Increase over reported trips:				
Optimum rates (%)	35	30	43	40
Maximum rates (%)	48[a]	46	53	55

[a]Maximum rates estimated for Baltimore, based on difference between optimum and maximum rates in other three areas.

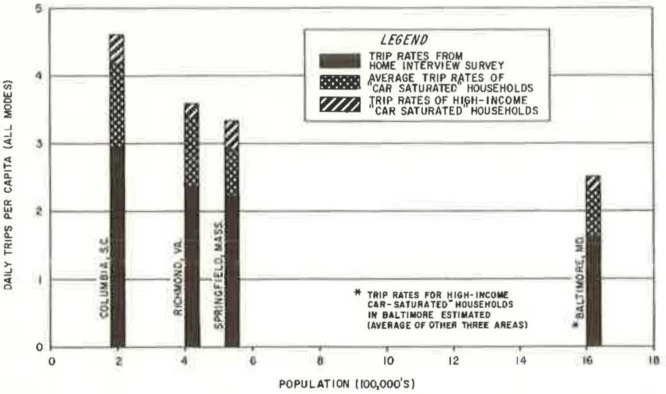


Figure 7. Trips per capita in four urbanized areas (survey data vs maximum potentials).

The trip rates (Table 7) have been applied to the population of households in each of the four study areas to develop estimates of trip-generation ceilings for the two extreme conditions described. The results of these computations are shown in Table 8 and have been plotted in Figure 7. (Detailed computations are shown in Appendix B.) Since data were not available for household incomes in Baltimore, optimum trip generation has been arbitrarily increased by 10 percent to develop an estimate of maximum trip potentials. This is based on the finding that maximum trip rates in the three areas for which income data were reported averaged about 10 percent greater than the optimum rates in those areas.

When trip rates for the four cities are examined for similarities, they are seen to vary in regular fashion, the smaller populations consistently generating trips at higher rates than the larger populations in every combination of family size and number of workers. This may, in part, relate to net residential density; in general, trip-making is inverse to the number of persons per net residential acre. Another possible explanation reflects the rise in average trip lengths as city size increases; fewer long trips can be accomplished in the time available for trip-making. Finally, social customs in an area also influence trip generation. (In Columbia, for example, many workers return home for the noon meal.)

Perhaps the most intriguing aspect of this analysis is the relatively small overall increase which results from the application of two such extreme sets of conditions. When the Springfield data were developed to show the constraints on travel by persons who do not have cars, it was noted that persons who had exclusive use of a car perform more trips than those without. Only about a fifth of the Springfield area population had access to cars which they did not have to share with other drivers. However, three-fourths of these drivers shared households with non-drivers and were, of course, called on for travel on behalf of the non-drivers—another form of constraint which results in the driver with dependents making more than the optimum amount of travel, as compared to patterns of trip-making by persons in households whose members all have cars. (Average per capita trip-making in these households is much lower than the optimum rate, of course.) From these studies, it was determined that fewer than 5 percent of the area residents were free to make as many trips (or as few) as needed to fulfill their wants.

It is somewhat astonishing, then, to realize that, despite the numerous constraints on travel which have been identified in these studies, the urban populace seems to come reasonably close to realizing its "theoretical" travel potentials under existing conditions. The optimum estimate of trip potential, according to the data given in Table 8, ranges between a 30 to 40 percent increase over the number of trips performed at the time the travel surveys were made, whereas the maximum rates under the assumptions of ideal income and mobility would lead to only 42 to 55 percent more trips. It is probable that even these trip rates overstate actual trip potentials for reasons noted earlier, because they are based on the most travel-oriented stratum of the population.

There are, of course, many other considerations which affect trip rates: some of the reasons why households within a given range of income are "car saturated" and others have no car at all relate to the personality and education of the householder and the relative importance he places on alternative uses for his money—purchasing a home, buying a boat, traveling abroad, sending a child to private school. The importance of mobility is also influenced by occupation (a traveling salesman must have a car), proximity to parks, shopping centers (which may allow participation in various activities without any vehicular transport), physical handicaps, and so on.

Potential Urban Travel—The discussion of optimum and maximum travel affords a basis for making estimates of the changes which very well may occur in urban trip-making as purchasing power continues to rise. (Most projections of urban development anticipate very real increases in purchasing power, and the analysis which follows can be used to approximate the effect of a given amount of change in purchasing power in each stratum of the urban population.)

Assume, for example, that the trip rates given in Table 5 are applied to a typical community of 500, 000 persons. Assume further that, on the average, median family income (purchasing power) is increased by $1, 000 (except for incomes over $15, 000). About 10 percent more trips would be expected to result. If incomes were increased $2, 000 (except in the highest increase category), an 18 percent gain in trips would probably result.

This analysis merely assumes that the average person from a household in a given income range, making the average number of daily trips for that income level, can be expected to increase his trip-making to the average levels associated with greater wealth as his income rises. Other aspects of this study have found that higher incomes are related to the number of workers in the household. They show, too, that the higher degree of mobility enjoyed by members of the richer households is achieved by use of the cars they own and that the extent of car use increases with income.

Travel, however, is not usually an end in itself, but is incidental to activities in which the trip-maker participates; his trips are usually made to bridge the distance between one activity and another. For activities such as the place of work, the costs of travel reduce net earnings but not enough to seriously offset the gains. However, participation in most nonwork activities requires expenditure of funds other than the cost of travel so that the number and variety of trips may be restricted by lack of resources to purchase desired goods or entertainment; travel costs may play only a minor role in the curtailment of travel. As incomes rise, power to travel and to purchase goods and service does result in more travel, and the foregoing relationships are general indicators of what to expect.

Transit Riding and Urban Travel Potentials

The significance of the foregoing discussion of urban travel potentials in relation to future bus transit patronage becomes apparent from a brief review of transit rider characteristics, and attitudes within the various study areas.

Aggregate Travel by Bus—The numbers and proportions of bus trips in the five study areas are given in Table 9.

Excluding the use of buses by school children, the number of trips made on buses was a very small portion of the travel performed in each area. Nonschool trips by bus accounted for a little over 10 percent of all person-travel in Baltimore, 7. 5 percent in Richmond, 2. 7 percent in Springfield, and less than 2. 5 percent in the Lehigh Valley and Columbia. When school trips are included, about 7 percent of all trips in Columbia, 9 percent in Lehigh, 10 percent in Springfield, 14 percent in Richmond, and 17 percent in Baltimore were made by bus.

A further analysis of travel mode and age of bus riders in Springfield (Table 10) reaffirms another well-known fact. Most adults traveled as auto drivers. More than three-fourths of all trips by persons 20 to 60 years of age were made as drivers (over

TABLE 9

TRIPS BY MODE
(Five Urbanized Areas)

Mode	Baltimore	Springfield	Richmond	Lehigh Valley	Columbia
			(a) Total Trips		
Public bus	332, 056	43, 351	80, 793	22, 781	14, 582
Public bus to school	(61, 305)	(11, 069)	(7, 552)	(7, 277)	(1, 094)
Nonschool	(270, 751)	(32, 282)	(73, 241)	(15, 504)	(13, 488)
School bus	122, 672	76, 916	46, 454	36, 264	25, 874
Auto driver	1, 467, 389	756, 112	570, 007	442, 028	363, 566
Auto, truck, taxi, pass.	753, 335	323, 637	275, 704	187, 013	176, 699
All modes	2, 675, 452	1, 200, 016	972, 958	688, 086	580, 721
			(b) Percentages of Trips by Mode		
Public bus	12. 4	3. 6	8. 3	3. 3	2. 5
Public bus to school	(2. 3)	(0. 9)	(0. 8)	(1. 0)	(0. 2)
Nonschool	(10. 1)	(2. 7)	(7. 5)	(2. 3)	(2. 3)
School bus	4. 6	6. 4	4. 8	5. 3	4. 5
Auto driver	54. 8	63. 0	58. 6	64. 2	62. 6
Auto, truck, taxi, pass.	28. 2	27. 0	28. 3	27. 2	30. 4
All modes	100. 0	100. 0	100. 0	100. 0	100. 0

80 percent by those in their 30's), whereas bus transit accounted for less than 2½ percent. Almost 60 percent of trips by persons over 70 years of age were made as drivers.

The largest relative use of bus was by people over 70 and in the age bracket between 16 and 19. However, the older persons made only 6 percent of the total bus trips, whereas persons in the 16 to 19 age bracket made nearly a quarter of all public bus trips. The teenage group was very mobile, considering that a relatively small proportion were employed, many were not licensed to drive, and those so licensed usually shared the family car. The bus was often the obvious alternative when others were using the car, and their per capita travel by bus was nearly twice that of the next ranking group (adults in the ages 40 to 60). Yet, although teenagers performed a major share of all bus travel in the Springfield area, it did not appear that special efforts had been made to market bus service to them.

The influence of walking distance on bus patronage is given in Table 11. More than a third of all homes in the 12-town Springfield "transit service area" were located

TABLE 10

NUMBER OF TRIPS BY MODE AND AGE OF TRIP-MAKER
(Springfield Urbanized Area, 1964-65)

Mode of Travel	Age								
	5-15	16-19	20-29	30-39	40-49	50-59	60-69	Over 70	Total
				(a) Number Trips					
Car driver	–	36, 855	136, 395	173, 530	204, 590	126, 810	59, 065	18, 150	755, 395
Car, truck, taxi, pass.	88, 915	39, 430	39, 825	37, 065	48, 785	36, 600	21, 590	10, 665	322, 875
Public bus	5, 675	9, 195	4, 140	2, 605	6, 425	6, 310	5, 440	2, 800	42, 590
School bus	58, 625	17, 525	–	–	–	–	–	–	76, 150
All modes	153, 215	103, 005	180, 360	312, 200	259, 800	169, 720	86, 095	31, 615	1, 197, 010
				(b) Mode as Percent of Trips in Age Bracket					
Car driver	–	35. 8	75. 6	81. 4	78. 7	74. 6	68. 6	57. 4	63. 1
Car, truck, taxi, pass.	58. 0	38. 3	22. 1	17. 4	18. 8	21. 7	25. 1	33. 7	27. 0
Public bus	3. 7	8. 9	2. 3	1. 2	2. 5	3. 7	6. 3	8. 9	3. 6
School bus	38. 3	17. 0	–	–	–	–	–	–	6. 3
All modes	100. 0	100. 0	100. 0	100. 0	100. 0	100. 0	100. 0	100. 0	100. 0
				(c) Percent of Trips in Each Mode by Age of Trip-Makers					
Car driver	–	4. 9	18. 1	22. 9	27. 1	16. 8	7. 8	2. 4	100. 0
Car, truck, taxi, pass.	27. 5	12. 2	12. 4	11. 5	15. 1	11. 3	6. 7	3. 3	100. 0
Public bus	13. 3	21. 6	9. 7	6. 1	15. 1	14. 8	12. 8	6. 6	100. 0
School bus	77. 0	23. 0	–	–	–	–	–	–	–
All modes	12. 8	8. 6	15. 1	17. 8	21. 7	14. 2	7. 2	2. 6	100. 0

TABLE 11

HOUSEHOLDS USING BUS VS WALKING DISTANCE TO BUS ROUTE
(Springfield Urbanized Area, 1964-65)

Distance, Home to Bus Line	All Households at Distance	Make Only Bus Trips	All or Some Trips by Bus	Households, Make No Trips: Number	Households, Make No Trips: Have No Cars
(a) Number of Households					
0 ft- 200 ft	47, 317	1, 989	4, 915	9, 092	6, 790
200 ft- 400 ft	21, 595	1, 069	3, 513	4, 913	3, 585
400 ft- 800 ft	24, 162	1, 151	3, 396	5, 306	4, 084
800 ft-1, 500 ft	25, 008	697	2, 450	7, 888	6, 322
Over 1, 500 ft	17, 479	180	1, 139	2, 306	1, 501
Total	135, 561	5, 086	15, 413	29, 505	22, 282
(b) Percent of Households Use Bus Within Each Increment of Distance to Bus Route					
0 ft- 200 ft	100	4. 2	10. 4	19. 2	14. 4
200 ft- 400 ft	100	4. 9	16. 3	22. 8	16. 6
400 ft- 800 ft	100	4. 8	14. 1	22. 0	17. 0
800 ft-1, 500 ft	100	2. 8	9. 8	31. 6	25. 3
Over 1, 500 ft	100	1. 0	6. 5	13. 2	8. 6
Total	100	3. 7	11. 4	21. 8	16. 5
(c) Percent of Households Use Bus According to Walking Distance to Bus Route					
0 ft- 200 ft	34. 9	39. 2	31. 9	30. 8	30. 5
200 ft- 400 ft	15. 9	21. 0	22. 8	16. 7	16. 1
400 ft- 800 ft	17. 8	22. 6	22. 0	18. 0	18. 3
800 ft-1, 500 ft	18. 5	13. 7	15. 9	26. 7	28. 4
Over 1, 500 ft	12. 9	3. 5	7. 4	7. 8	6. 7
Total	100. 0	100. 0	100. 0	100. 0	100. 0

Note: Data are for all households in a 12-town "transit service area" centered in Springfield.

within 200 ft of a bus route, more than half within 400 ft of transit service; nearly 70 percent were closer than 800 ft. Of the 30 percent of all dwellings more than 800 ft from a local bus route, about two-fifths were beyond 1, 500 ft (more than a quarter of a mile from bus service).

Considering households which use only the bus, 39 percent were within 200 ft of a bus route, 60 percent within 400 ft, and 83 percent within 800 ft. Nearly all bus riders lived within 1, 500 ft of a bus route. (There is good correspondence between the distribution of dwelling units and bus travelers by distance from the bus line. The "index of concentration" between the percent of dwelling units, p_1, and the percent of people who make bus trips, p_2, was 85 percent. This index is defined as $100 - \frac{1}{2} \Sigma | p_1 - p_2 |$. Perfect concentration or correspondence would equal 100.)

Data were also examined to see if car ownership was a factor in determining the proportion of households which generated no trips at all. Households from which no trips were made accounted for 19 to 23 percent of all dwellings within 800 ft of a bus line and nearly a third of the homes at 800 to 1, 500 ft; only 13 percent of the homes located more than a quarter mile from the bus produced no travel.

TABLE 12

AVERAGE DAILY CHOICE AND CAPTIVE PUBLIC TRANSIT (BUS) TRIPS

Urbanized Area	All Transit Trips: Number	All Transit Trips: Percent of All Trips	Choice Trips: Number	Choice Trips: Percent of Bus	Captive Trips: Number Potential Drivers	Captive Trips: Percent of Bus	Captive Trips: Number No Driver Potential	Captive Trips: Percent of Bus	Captive Trips: All Bus
Columbia, S. C.	14, 582	2. 5	630	4. 3	1, 190	8. 2	12, 762	87. 5	100. 0
Lehigh Valley, Pa.	22, 781	3. 3	2, 040	9. 0	2, 320	10. 2	18, 421	80. 8	100. 0
Richmond, Va.	80, 793	8. 3	7, 280	9. 0	7, 940	9. 8	65, 573	81. 2	100. 0
Springfield, Mass.	43, 396	3. 6	2, 600	6. 0	4, 825	11. 1	35, 971	82. 9	100. 0
Baltimore, Md.	332, 056	12. 8	24, 020	7. 2	26, 220	7. 9	281, 816	84. 9	100. 0

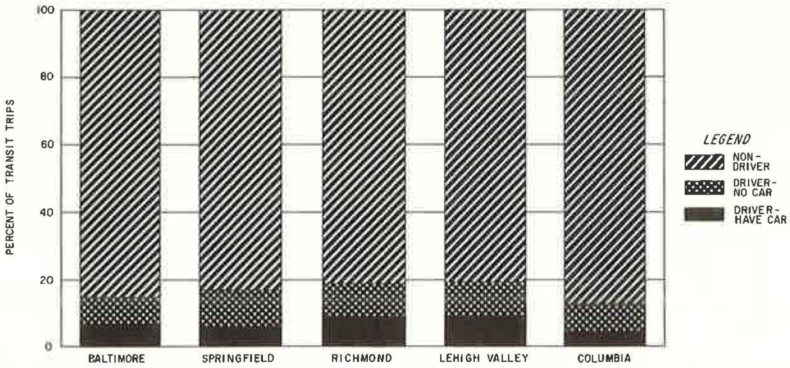


Figure 8. All bus transit trips classified as: captive (non-drivers and drivers without cars) and choice (licensed drivers with cars), five urbanized areas.

About three-quarters of the households which made no trips were without cars. This proportion ranged from 71 to 77 percent of the dwellings within 800 ft of a bus route, increased to 80 percent of those 800 to 1,500 ft from bus service, and decreased to only 65 percent of those over a quarter of a mile away. Thus, areas over 1,500 ft from bus routes contained the smallest proportion of homes which generated no trips, and households which made no trips at that distance were more likely to have a car than those closer to the bus route.

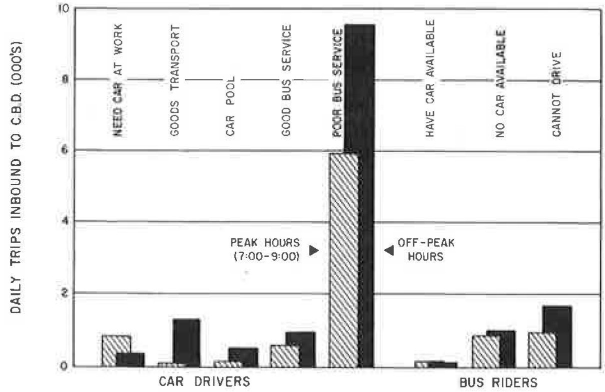
Choice and Captive Transit Riders—Efforts were made to class bus travelers as "choice" and "captive" in the study cities. The classification was based on stratification of origin-destination data according to car ownership and eligibility to drive. "Choice" transit riders were defined as those bus riders who (a) had a car available for use, and (b) had a driver's license. "Captive" riders included (a) those who were not licensed drivers, and (b) those potential drivers who were licensed but did not have a car available at the time of travel (Table 12, and Fig. 8). In this study, "choice" bus riders included only persons who drove a car to the bus line, then completed the trip by bus, or those bus riders whose car remained at place of residence during the entire time they were away from home.

Choice riders accounted for 9.0 percent of all bus trips in the Richmond and Lehigh Valley areas, 7.2 percent in Baltimore, 6.0 percent in Springfield, and 4.3 percent in Columbia. When related to overall person trips by all modes, however, choice bus riders accounted for a very small fraction of all urban trips, ranging from about 1.0 percent of the trips in Baltimore to only one-tenth that proportion in Columbia. The proportion of choice riders in Baltimore appears to be less than that found by other investigations for cities of comparable size; this may be the result of different definitions of choice riders (10, 11).

The significance of city size is also apparent in Table 12. The Baltimore urbanized area, with a population equal to all four smaller cities, generated more than twice as many transit trips as the other four areas combined. Springfield and Richmond urbanized areas, at first glance, appear to be reversed in terms of transit travel, but about a third of the Springfield area population was oriented toward outlying town centers and had no direct transit service to Springfield. (Springfield is a polynucleated urban region.) Richmond, therefore, had a larger service area and, by virtue of a more concentrated business center, supported a much larger transit operation.

Those persons who chose to ride the bus in place of the car available to them, definitely exhibit characteristics and behavior patterns which differ in some degree from other bus riders. In Richmond, for example:

1. More than half of the choice riders had a car available for their exclusive use. (Either the bus rider was the only household member with a driver's license, or there were as many cars in the household as persons eligible to drive.)



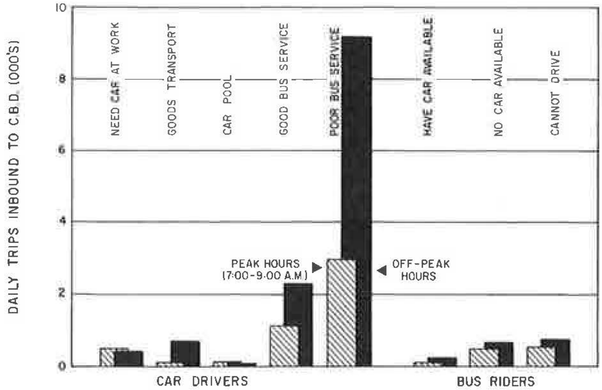


Figure 9. Attitudes of persons traveling to CBD: drivers—need for car and availability of bus; bus riders—car availability and eligibility to drive. (a) Springfield urbanized area, 1964-65, and (b) Allentown CBD - Lehigh Valley urbanized area, 1964-65.

2. About one-fifth of the choice riders were "park and ride" patrons; i. e., they drove to bus stops and parked, continuing their trips on the bus. (The proportion of park and ride trips was much less in Baltimore and other study areas than in the Richmond area, suggesting that there may have been special aspects of the bus service in Richmond which had a positive influence on choice riding.)

3. More than 80 percent of the choice bus riders were from households of middle and upper incomes. (Only 18 percent of the choice riders were generated in the third of households with incomes under $5,000.)

4. More than 90 percent of the choice bus riders were engaged in travel to work, whereas 48 percent of the captive riders were traveling to or from nonwork activities.

5. Nearly two-thirds of all bus riders in Richmond were women, and this proportion holds true for both choice and captive trips. In car-owning households, the disproportionate number of women using the bus was not a matter of the male head-of-household preempting the family car. The ratio of men to women was virtually the same among choice riders, whether they came from households where cars equaled the number of licensed drivers, or from households where there were fewer cars than qualified drivers.

To summarize, the use of buses in the study areas was largely by persons who had no ready alternative. Of those who appeared to have made a choice (a car was at home during the time they were away), there is strong likelihood that some, perhaps most, did not really have access to a private vehicle; although they were qualified to drive, the car was not theirs, it was not in operable condition, or they did not have permission to use it. This is especially probable of the junior members of households.

The aparent conclusion, then, is that the quality of bus transit available in the study cities was relatively unattractive when compared with the car so that most who used it were captive to it. The clearly defined exceptions were few (213 actual trip reports in the 5 percent sample of dwelling units in Richmond, made by about half that many different persons from households with as many cars as licensed drivers), making it difficult to derive a meaningful service-responsive formula for computing choice of mode between alternative forms of transport in these cities.

Attitudes Toward Bus Use—The validity of this assertion was confirmed in an independent analysis of questions directed to respondents in home interviews concerning the availability of alternatives to the modes used in travel, whether performed in car or bus.

Results of attitude studies in the Springfield, Massachusetts, and Lehigh Valley (Allentown), Pennsylvania, areas are shown in Figure 9. In both areas, respondents expressed similar attitudes. Most respondents preferred to drive; however, a small number of transit riders preferred the bus to the car. Data for Springfield are based on over 1,000 direct-interview trip reports relating to trips which had Springfield CBD destinations. Data for Allentown are based on about 2,000 trip reports.

In both Springfield and Allentown, the majority of drivers reported that bus service was not frequent enough to suit their purposes, especially during off-peak hours. Many drivers admitted they could have used the bus and had no special need for their cars other than for the trip from home and return, which may be interpreted as a negative attitude toward the bus. This attitude was most evident in the large proportion of drivers (78 percent of CBD drivers in Springfield, 69 percent in Allentown) who regarded bus service as "infrequent or lacking" when confronted with present transit service levels.

Most of these drivers originated within 15 min driving time of Springfield CBD and 10 min of Allentown CBD. These central areas were the focus of transit service in both communities. Thus, it seems likely that factors other than transit service frequency also discouraged bus patronage. Some of the drivers lived a considerable distance from the bus route, and this probably affected their choice.

The attitude studies suggest that those persons who traveled to the CBD as drivers did not prefer to use bus transit as it existed at the time of the surveys. These findings reflect attitudes in middle-sized urban areas without major problems of street congestion to delay the car, and no separate rights-of-way which might permit transit to provide a rapid service. Under the circumstances, these attitudes are probably typical of inhabitants in similarly sized urbanized areas throughout the country.

SOME IMPLICATIONS FOR MAXIMIZING BUS TRANSIT POTENTIALS

The purpose of the study has been to identify some of the potentials for bus transport in medium-sized American cities in terms of today's travel market. Within this context, wherein lies the significance of the analyses?

The following implications arise from the work done to date:

1. In the lower range of middle-sized cities (under 250,000 population), increases in transit usage on approaches to the CBD would have relatively small effects on reducing peak-hour highway lane requirements.

2. In cities near the upper limit of the size range (750,000 to 1,000,000 population), street and highway improvements might be substantially reduced by retaining and increasing bus transit patronage. Corridors of travel are typically near vehicle saturation levels on the CBD approaches and relatively small increments of vehicular traffic can make the difference between congestion and free-flow at periods of peak travel demand.

3. Improvements in income or mobility levels tend to increase trip-making within the urbanized area. If this mobility increase could be achieved through improvements in public transport operations, it might afford a substantial new market for transit patronage. It is even conceivable that new travel might exceed diversion from automobile travel. Most of the added travel would be for nonwork purposes at off-peak hours.

4. Some of the benefits that might result from improved transit would be increased mobility for underprivileged or deprived strata of the population. These potentials may possibly exceed those resulting from relief to highways. A revitalized bus transit service might also relieve drivers of trips which are primarily motivated to accommodate non-drivers. In all of the study areas, large numbers of auto driver trips were made to "serve-passenger" rather than to attend to an activity of the driver. Such trips ranged from 18 to 23 percent of the driver trips in all urbanized areas except Richmond. In Richmond, "serve-passengers" accounted for less than 11 percent of the drivers in the Richmond urbanized area (and resulted in higher percentages of trips for other purposes). This difference probably relates to the high level of transit use in the Richmond area.

5. Most transit riding in small- and medium-sized cities is performed by people who are essentially "captive" to this mode. Studies related to the attitudes of persons who use their cars rather than the bus, when they have a choice, show that bus service is not as satisfactory as the car in the opinion of trip-makers in the areas chosen for study. This does not mean that public transit cannot be an attractive and preferred mode of travel, but simply that it does not now present this appearance.

6. Stated in other terms, conventional transit media have difficulty competing with the car when travel by bus requires substantially more time. To achieve gains in transit riding, it is likely that new concepts in transit will be required. These may involve more extensive use of jitney services as well as consolidation of public bus, school bus, and taxi operations.

7. In larger cities, where transit seems to have potential for substantial peak-hour capacity relief, further attention might be given to improved line-haul and downtown distribution facilities (viz. central-area bus subways or transitways through urban renewal projects).

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Appendix A

TRIP GENERATION RATES RELATED TO FAMILY SIZE, NUMBER OF WORKERS AND CAR OWNERSHIP
(Springfield Urbanized Area, 1964-65)

No. of Persons	No. of Workers		No. of Cars		
			0	1	2+
1	0	Trips	10, 886	10, 702	–
		Households	13, 550	3, 734	–
		Trips/households	0. 80	2. 87	
		Trips/persons	0. 80	2. 87	
1	1	Trips	7, 021	23, 502	–
		Households	6, 505	6, 868	–
		Trips/households	1. 08	3. 43	
		Trips/persons	1. 08	3. 43	
2	0	Trips	7, 659	30, 706	1, 873
		Households	7, 825	7, 137	299
		Trips/households	0. 98	4. 30	6. 26
		Trips/persons	0. 49	2. 15	3. 13
2	1	Trips	6, 753	74, 067	21, 601
		Households	3, 219	13, 242	2, 831
		Trips/households	2. 10	5. 63	7. 64
		Trips/persons	1. 05	2. 81	3. 82
2	2	Trips	1, 723	59, 668	24, 911
		Households	621	8, 012	3, 086
		Trips/households	2. 77	7. 46	8. 08
		Trips/persons	1. 39	3. 72	4. 04
3	0	Trips	1, 566	7, 066	472
		Households	864	1, 192	78
		Trips/households	1. 81	5. 93	6. 05
		Trips/persons	0. 60	1. 98	2. 02
3	1	Trips	3, 952	68, 083	26, 803
		Households	1, 166	9, 746	2, 851
		Trips/households	3. 39	7. 00	9. 40
		Trips/persons	1. 13	2. 33	3. 13
3	2+	Trips	3, 010	53, 328	40, 712
		Households	691	5, 818	4, 185
		Trips/households	4. 36	9. 15	9. 73
		Trips/persons	1. 45	3. 05	3. 24
4	0	Trips	1, 772	2, 820	552
		Households	772	426	72
		Trips/households	2. 30	6. 61	7. 67
		Trips/persons	0. 58	1. 65	1. 92
4	1	Trips	3, 513	88, 668	43, 394
		Households	885	10, 566	3, 450
		Trips/households	3. 97	8. 40	12. 57
		Trips/persons	0. 99	2. 10	3. 14
4	2+	Trips	2, 268	46, 826	52, 333
		Households	447	4, 235	3, 608
		Trips/households	5. 07	11. 06	14. 50
		Trips/persons	1. 27	2. 77	3. 63
5+	0	Trips	4, 274	7, 861	918
		Households	785	689	86
		Trips/households	5. 45	11. 40	10. 68
	(Avg. = 6 Pers.)	Trips/persons	0. 91	1. 90	1. 78
5+	1	Trips	6, 270	183, 873	74, 366
		Households	1, 461	17, 131	4, 620
		Trips/households	4, 30	10. 73	16. 10
	(Avg. = 6 Pers.)	Trips/persons	0. 72	1. 80	2. 68
5+	2+	Trips	1, 487	62, 215	51, 180
		Households	305	4, 803	3, 400
		Trips/households	4. 88	12. 94	15. 05
	(Avg. = 6 Pers.)	Trips/persons	0. 81	2. 16	2. 51

Appendix B

ESTIMATES OF "OPTIMUM" AND "MAXIMUM" TRIP GENERATION

BALTIMORE URBANIZED AREA
(O-D Survey, 1961-62)

No. of Persons	No. of Workers	Actual Trips	No. of Households	Optimum Trips[a]	
				Trip Rate	No. Trips
1	0	20, 240	30, 381	2. 0	60, 762
1	1	67, 531	31, 531	3. 0	94, 593
2	0	40, 381	24, 605	4. 0	98, 420
2	1	245, 176	63, 702	6. 0	283, 212
2	2	203, 567	37, 704	6. 5	243, 126
3	0	13, 892	6, 093	6. 0	36, 558
3	1	265, 405	49, 258	8. 0	394, 064
3	2	194, 881	29, 604	8. 5	250, 634
3	3	42, 436	5, 687	9. 0	51, 183
4	0	7, 596	3, 577	6. 0	21, 462
4	1	330, 675	49, 058	9. 0	441, 523
4	2	178, 370	22, 532	9. 5	214, 054
4	3	52, 915	5, 898	10. 0	58, 980
4	4	9, 742	1, 091	10. 5	11, 456
5	0	13, 439	5, 378	8. 0	43, 024
5	1	458, 197	62, 913	11. 0	692, 043
5	2	230, 893	27, 352	11. 5	314, 548
5	3	96, 233	9, 889	12. 0	118, 668
5	4	29, 575	2, 678	12. 5	33, 475
5	5	8, 223	726	13. 5	9, 801
Total		2, 509, 002	469, 357		3, 603, 042

[a]Detailed estimates of maximum trips not made for Baltimore, since income data were not collected in the O-D Survey.

SPRINGFIELD URBANIZED AREA
(O-D Survey, 1964-65)

No. of Persons	No. of Workers	Actual Trips	No. of Households	Optimum Trips		Maximum Trips	
				Trip Rate	No. Trips	Trip Rate	No. Trips
1	0	21, 588	17, 284	3. 0	51, 852.	3. 65	63, 087
1	1	30, 543	13, 373	4. 0	53, 492	5. 2	69, 540
2	0	40, 238	15, 261	6. 0	91, 566	7. 0	106, 827
2	1	102, 421	19, 292	8. 0	154, 336	8. 25	159, 159
2	2	86, 302	11, 719	8. 5	99, 612	9. 5	111, 331
3	0	9, 104	2, 134	6. 5	13, 871	8. 0	17, 072
3	1	98, 838	13, 763	10. 0	137, 630	14. 0	192, 682
3	2	97, 050	10, 694	10. 0	106, 940	11. 2	119, 773
4	0	5, 144	1, 270	8. 3	10, 541	8. 3	10, 541
4	1	135, 575	14, 901	12. 3	183, 282	13. 0	193, 713
4	2	101, 427	8, 290	14. 7	121, 863	15. 8	130, 982
5	0	13, 053	1, 560	12. 5	19, 500	13. 5	21, 060
5	1	264, 509	23, 212	16. 0	371, 392	17. 5	406, 210
5	2	114, 882	8, 508	17. 0	145, 136	18. 0	153, 144
Total		1, 120, 674	161, 251		1, 561, 013		1, 755, 121

RICHMOND URBANIZED AREA
(O-D Survey, 1964-65)

No. of Persons	No. of Workers	Actual Trips	No. of Households	Optimum Trips		Maximum Trips	
				Trip Rate	No. Trips	Trip Rate	No. Trips
1	0	8,613	5,732	3.0	17,196	4.0	22,928
1	1	24,553	7,722	4.0	30,888	6.0	46,332
2	0	21,879	7,721	6.0	46,326	6.0	46,326
2	1	83,943	16,142	7.0	112,994	7.75	125,100
2	2	102,743	14,363	8.0	114,904	9.0	129,267
3	0	5,662	1,398	9.0	12,582	10.0	13,980
3	1	92,231	12,939	10.5	135,860	11.25	145,564
3	2	87,442	9,804	10.5	102,942	11.50	112,746
3	3	18,667	1,704	12.0	20,448	12.25	20,874
4	0	3,723	460	11.5	5,290	13.5	6,210
4	1	121,053	12,378	13.5	167,103	14.25	176,387
4	2	81,452	7,469	14.0	104,566	14.50	108,300
4	3	29,473	2,549	16.0	40,784	17.0	43,333
5	0	2,501	480	14.0	6,720	15.0	7,200
5	1	86,496	7,977	16.5	131,621	16.7	133,216
5	2	42,462	3,563	17.5	62,353	18.0	64,134
5	3	16,131	1,285	18.0	23,130	18.5	23,772
6	0	886	213	15.0	3,195	16.0	3,408
6	1	42,132	3,856	18.0	69,408	19.0	73,264
6	2	20,257	1,747	20.0	34,940	21.0	36,687
6	3	10,316	835	24.0	20,040	25.0	20,875
7	0	1,316	272	17.75	4,828	18.5	5,032
7	1	22,451	2,335	20.5	47,867	21.0	49,035
7	2	17,485	1,489	25.5	37,970	26.0	38,714
7	3	12,020	999	32.0	31,968	33.0	32,967
Total		954,432	125,432		1,385,923		1,485,651

COLUMBIA URBANIZED AREA
(O-D Survey, 1964-65)

No. of Persons	No. of Workers	Actual Trips	No. of Households	Optimum Trips		Maximum Trips	
				Trip Rate	No. Trips	Trip Rate	No. Trips
1	0	12,417	8,389	3.0	25,167	4.0	33,556
1	1	14,070	3,627	5.0	18,135	6.0	21,762
2	0	12,713	2,601	8.0	20,808	9.0	23,409
2	1	49,802	6,727	9.0	60,543	10.5	70,634
2	2	46,524	5,114	10.0	51,140	12.0	61,362
3	0	5,582	1,089	12.0	13,068	14.0	15,246
3	1	56,267	5,743	12.75	73,223	15.5	89,017
3	2	51,980	4,402	13.50	59,427	16.0	70,432
3	3	9,668	770	15.00	11,550	16.5	12,705
4	0	2,099	336	15.00	5,040	16.0	5,376
4	1	65,189	5,175	16.75	86,681	18.0	93,150
4	2	54,245	3,641	17.50	63,718	19.0	69,179
4	3	11,567	777	19.0	14,763	19.5	15,151
5	0	1,931	258	16.00	4,128	17.0	4,386
5	1	51,632	3,606	20.75	74,825	22.0	79,332
5	2	22,309	2,241	21.50	48,181	22.0	49,302
5	3	10,343	582	23.00	13,386	24.0	13,968
6	0	2,496	346	22.00	7,612	22.0	7,612
6	1	41,629	3,075	24.75	76,106	25.5	78,413
6	2	30,799	2,146	25.50	54,723	26.5	56,869
6	3	14,623	1,066	27.00	28,782	28.5	30,381
Total		567,885	61,711		811,006		901,248

Relationship of Passenger-Car Age and Other Factors to Miles Driven

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This report presents empirical data on the effects of passenger-car age, multicar ownership, and other factors on miles traveled by automobiles. Odometer readings and estimated annual miles traveled by year model were analyzed. The data analyzed came from three home-interview surveys. Two of these surveys were motor-vehicle-use studies conducted in Illinois and Montana and the third survey was conducted by the Bureau of the Census.

•THIS report presents data from several studies which show certain factors affecting passenger-car mileage. The data include average yearly mileages driven in single and multicar households, average odometer readings according to age of car, cars bought new or used and major body type. By analyzing such empirical data on the characteristics of passenger-car ownership and use, basic relationships will be developed which should be useful in predicting future levels of motor-vehicle ownership and travel demands.

BACKGROUND

Three principal sets of data are used in this paper. The first set was obtained from the National Automobile Use Study conducted by the Bureau of the Census for the Bureau of Public Roads in April 1961, and supplemented by additional data obtained in June 1962. The sample used by Census for this study was a Current Population Survey panel of approximately 4,000 households. The households selected in the sample were asked, among other items, the number of automobiles owned and their year models, the odometer reading of each vehicle, and the estimated miles traveled by each car in the preceding 12 months. In June 1962, the Census Bureau wrote to the head of each sampled household asking if the vehicle included in the original sample was still being operated from that household, and, if so, what was its current odometer reading. About 1,500 usable records were obtained from this resurvey. For purposes of this report, the records for 15 months were adjusted to represent estimates of one year of travel.

The other two sets of data were some unpublished findings developed from the Illinois and Montana motor-vehicle-use studies, the former conducted from September 1957 through August 1958 and the latter from July 1963 through June 1964. Both of these studies were conducted as highway planning projects by the respective state highway departments in cooperation with the Bureau of Public Roads. Standard statistical sampling techniques were used in which selections are made on a probability basis. The data for each household were obtained by personal interview. The sample design reflected both rural and urban characteristics of each of the states. The studies provided for a full-year coverage, with the interview samples in each population group divided into four equal segments and a sampling taken in each season.

Paper sponsored by Committee on Economic Forecasting and presented at the 46th Annual Meeting.

TABLE 1

PERCENTAGE DISTRIBUTION OF PASSENGER CARS BY AGE, FOUR STUDIES

Age of Passenger Car (years)[1]	R. L. Polk and Co. July 1, 1961[2]		National Automobile Use Study, April 1961[3]		R. L. Polk and Co. July 1, 1964[2]		Montana Motor-Vehicle-Use Study, 1963-1964	
	Actual	Cumulative	Actual	Cumulative	Actual	Cumulative	Actual	Cumulative
Under 1	6.5	6.5	6.9	6.9	8.9	8.9	5.0	5.0
1-2	10.5	17.0	16.4	23.3	11.1	20.0	11.7	16.7
2-3	9.9	26.9	12.2	35.5	10.0	30.0	9.6	26.3
3-4	7.4	34.3	9.0	44.5	8.3	38.3	9.5	35.8
4-5	10.1	44.4	11.4	55.9	9.3	47.6	9.3	45.1
5-6	9.8	54.2	10.5	66.4	8.5	56.1	9.3	54.4
6-7	10.9	65.1	10.7	77.1	6.0	62.1	6.8	61.2
7-8	7.0	72.1	6.1	83.2	7.7	69.8	8.2	69.4
8-9	7.8	79.9	6.8	90.0	7.1	76.9	6.1	75.5
9-10	4.2	84.1	1.9	91.9	7.1	84.0	7.3	82.8
10-11	4.9	89.0	2.1	94.0	4.0	88.0	3.8	86.6
11-12	4.8	93.8	3.1	97.1	3.7	91.7	3.6	90.2
12 and over	6.2	100.0	2.9	100.0	8.3	100.0	9.8	100.0
Total	100.0	—	100.0	—	100.0	—	100.0	—
Year not given, number	181(000)				52(000)			

[1]Each class interval includes lower, but not higher age than that shown.
[2]From (1) and (2). Data used here by permission of R. L. Polk and Co.
[3]Includes only those vehicles for which 1962 data were collected.

Reliability of Data

To evaluate the reliability of the distribution of vehicles by age, the percentage distributions of vehicles found in two of the surveys were compared with a similar distribution of passenger cars by age reported by R. L. Polk and Company as of July 1, 1961 (1), and July 1, 1964 (2). Although the tables prepared by Polk represent an adjusted registration count to July 1 of each year, these registrations are considered representative of the distribution for the entire year. From data in Table 1, a comparison can be made of the Polk (1) data and the national study data for 1961. A similar comparison can be made of the 1964 (2) Polk data and the Montana data collected from July 1, 1963, to June 30, 1964. The cumulative frequency distributions from these studies are shown in Figure 1.

Results from the national study in 1961 compared fairly well with those from the 1961 Polk (1) survey for some years. But the percentages shown for the national studies are generally larger than the Polk figures for cars less than 6 years old, and

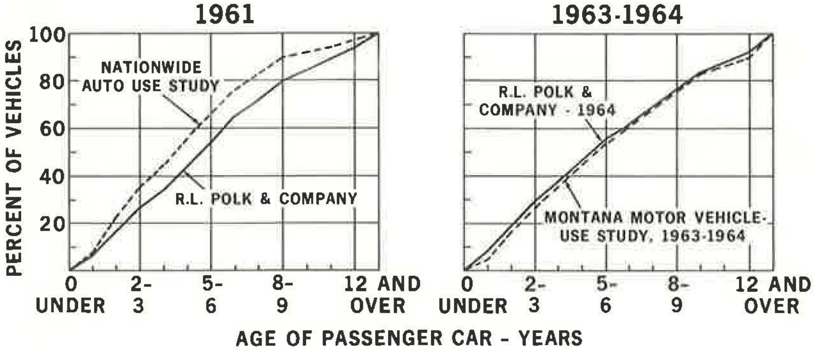

Figure 1. Cumulative frequency distributions of vehicles by age.

TABLE 2

AVERAGE ANNUAL MILES TRAVELED BY PASSENGER CARS BETWEEN 1961 AND 1962

Year Model[1]	Age of Car (years)	Average Annual Travel	Number of Vehicles in Sample
1961	Less than 1½	13,200	99
1960	1½-2½	12,000	235
1959	2½-3½	11,000	175
1958	3½-4½	9,600	129
1957	4½-5½	9,400	164
1956	5½-6½	8,700	153
1955	6½-7½	8,600	153
1954	7½-8½	8,100	88
1953	8½-9½	7,000	99
1952	9½-10½	7,300	28
1951	10½-11½	4,900	37
1950	11½-12½	5,700	47
1949 and older	12½ and older	4,300	46
All years		9,400	1,453

[1] National Automobile Use Study conducted for Public Roads by the Bureau of the Census, 1961-1962. Summary data obtained from two odometer readings, one in April 1961 and another on identical vehicle in June 1962. Data were adjusted to represent estimates of 12 months of travel.

smaller for cars more than 6 years old. The largest difference was for cars 9 years and older. For the Polk study, 20.1 percent of the cars sampled were 9 years old and older, for the national study, 10.0 percent.

The percentage distribution of cars by age for the Montana study and the 1964 Polk study (2) were in close agreement for all age groups of cars except those less than one year old. The difference for cars less than one year old may have been caused by

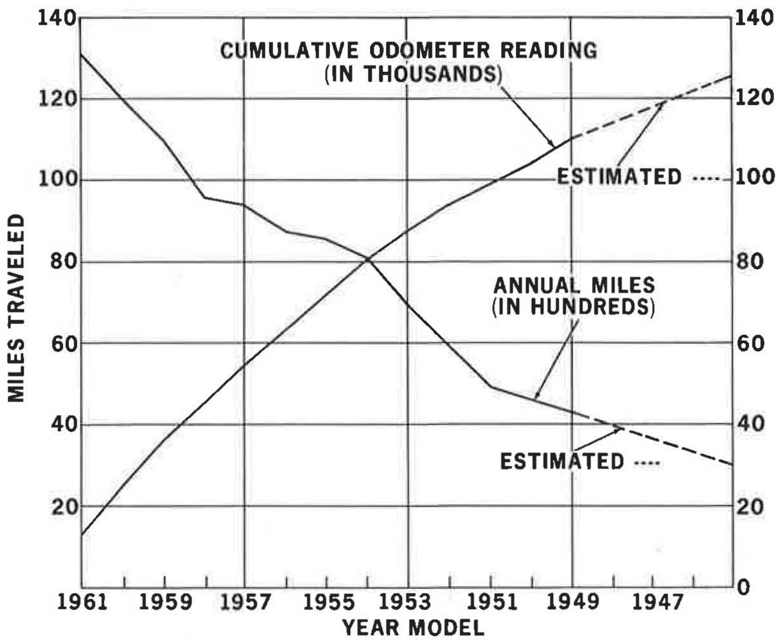

Figure 2. Average annual miles traveled between 1961 and 1962 and cumulative odometer readings by year model.

TABLE 3

AVERAGE ODOMETER READING BY AGE AND YEAR MODEL OF PASSENGER CARS REPORTED IN TWO STUDIES

Age (years)[1]	National Automobile Use Study, April 1961[2]			Montana Motor-Vehicle-Use Study, 1963-1964[3]		
	Year Model	Number of Vehicles in Sample	Average Odometer Reading (mi)	Year Model	Number of Vehicles in Sample	Average Odometer Reading (mi)
Under 1	1961	99	3,100	1964	114	5,200
1-2	1960	235	11,700	1963	267	12,400
2-3	1959	175	21,900	1962	219	21,900
3-4	1958	129	30,200	1961	217	31,700
4-5	1957	164	40,700	1960	212	39,800
5-6	1956	153	46,500	1959	212	45,300
6-7	1955	153	51,400	1958	155	52,200
7-8	1954	88	54,700	1957	187	56,900
8-9	1953	99	61,500	1956	138	64,700
9-10	1952	28	67,100	1955	167	72,700
10-11	1951	37	66,400	1954	87	78,300
11-12	1950	47	66,900	1953	81	76,000
12 and over	1949 and earlier	46	70,000	1952 and earlier	222	87,500
	All years	1,453	36,800	All years	2,278	46,400
Average age			4.9 years			6.1 years

[1] Each class interval includes lower, but not higher age than that shown.
[2] Includes only those vehicles for which 1962 data were obtained.
[3] Includes only those vehicles for which odometer readings were available; thus, average age shown differs from average age shown in text table in section on multicar households.

the fact that the Montana data represent a study conducted over 12 months while the Polk data represent an adjusted registration count to July 1 of each year. Further, the Polk data are national while the Montana data are for one state.

TABLE 4

AVERAGE ODOMETER READINGS BY YEAR MODEL FOR CARS BOUGHT NEW AND THOSE BOUGHT USED BY REPORTING OWNERS[1]

Year Model	Passenger Cars Bought New			Passenger Cars Bought Used		
	Number	Percent	Average Odometer Reading (mi)	Number	Percent	Average Odometer Reading (mi)
1964	112	9.9	5,200	2	0.2	3,600
1963	243	21.4	11,900	24	2.1	17,100
1962	176	15.5	20,000	43	3.8	29,900
1961	136	12.0	30,400	81	7.1	33,900
1960	108	9.5	38,300	104	9.1	41,300
1959	106	9.4	40,000	106	9.3	50,700
1958	46	4.1	47,600	109	9.5	54,200
1957	57	5.0	53,900	130	11.4	58,300
1956	30	2.6	56,200	108	9.4	67,100
1955	36	3.2	70,700	131	11.4	73,200
1954	18	1.6	64,900	69	6.0	81,900
1953	15	1.3	74,000	66	5.8	76,400
1952	9	0.8	63,900	45	3.9	78,300
1951	14	1.2	71,100	40	3.5	87,100
1950	13	1.2	79,300	34	3.0	88,000
1949 and earlier	15	1.3	90,900	52	4.5	104,900
All years	1,134	100.0	–	1,144	100.0	–

[1] Montana motor-vehicle-use study, 1963-1964.

ANNUAL TRAVEL BY CAR AGE

The average miles that passenger cars travel in a year are related to their age. For example, when an automobile is new, its owner is likely to take more frequent trips. Table 2 gives, by year, model and age of car, the average miles traveled by passenger cars between 1961 and 1962 as reported in the National Automobile Use Study. This information is shown in Figure 2 along with the cumulative mileage by age of car.

The information shown in Table 2 and Figure 2 is based on about 1,500 records of travel derived from two odometer readings on the same vehicle, one in April 1961 and the other in June 1962. The data were adjusted to represent estimates for 12 months. From the 4,000 households surveyed in April 1961, it was possible to obtain about 1,500 responses in June 1962. Some vehicles were sold or traded between April 1961 and June 1962. To the extent that the driving experience of those responding to the June 1962 inquiry may not be typical of the total sample, bias may be present in the tabulation.

Data show that as car age increases, annual miles of travel decrease. A yearly average of 9,400 miles was traveled by all year models in the study, a figure that agrees closely with Bureau of Public Roads published averages of 9,465 miles in 1961 (3) and 9,435 miles in 1962 (4).

Another related area investigated was odometer readings by age and year model of passenger cars. Table 3 gives this information which was developed from the National Automobile Use Study and the Montana motor-vehicle-use study. The average odometer readings from the two surveys compare favorably, except for cars less than one year old and for cars 9 years or older. For cars less than one year old, the differences in odometer readings from the two surveys may have occurred because the national survey consisted of data collected during only one week in April 1961 and the Montana survey data were collected between July 1963 and June 1964. Also, one-tenth of the vehicles reported in the national study were in the older car group (9 years or older) as compared with one-fourth of the vehicles reported in the Montana study. With proportionately more older vehicles found in the Montana study, the average odometer reading was 46,400 miles as compared with 36,800 miles in the national study. The average age of all cars sampled was 4.9 years in the national study and 6.1 years in the Montana study.

NEW AND USED CARS

The average odometer readings by year model for cars bought new or bought used by the reporting owner were also considered. This information, based on the Montana study, is given in Table 4. The difference in the odometer mileage on 1964 cars purchased new or used by the reporting owner was not significant because there were too few used cars purchased. However, when the vehicles were 2 and 3 years old—the 1962 and 1963 year models—the difference in odometer readings between cars reported by the owner as purchased new or purchased used was large. A possible reason for the large difference in readings might be that many of the second-owner vehicles having large mileages were originally operated by salesmen, utility companies, and rental agencies, and were kept for only a year or two before being traded. For the 1961 and 1960 models, the average odometer readings for cars purchased used were about 3,000 miles more than for cars purchased new. Vehicles 5 years old or older that were purchased used—1959 year model and older—had much higher average odometer readings than cars purchased new. Possibly, many of the drivers who purchase a new car and keep it more than 5 years are low mileage drivers.

The number and percentage distribution by year model for cars bought new or used are also given in Table 4. A large percentage of the passenger cars purchased new by the reporting owner were late model cars—almost 60 percent were 1961 through 1964 year models. Conversely, a large percentage of the cars purchased used by the reporting owner were older vehicles—almost 60 percent were 1957 models or older.

The proportion of cars purchased new or used for each year model was also considered in this analysis. Table 5 gives this information, which is based on the Montana

TABLE 5

PROPORTION OF PASSENGER CARS OF EACH YEAR MODEL BOUGHT NEW AND PROPORTION BOUGHT USED BY REPORTING OWNER[1]

Year Model	New	Used
1964	98.2	1.8
1963	91.0	9.0
1962	80.4	19.6
1961	62.7	37.3
1960	50.9	49.1
1959	50.0	50.0
1958	29.7	70.3
1957	30.5	69.5
1956	21.7	78.3
1955	21.6	78.4
1954	20.7	79.3
1953	18.5	81.5
1952	16.7	83.3
1951	25.9	74.1
1950	27.7	72.3
1949 and earlier	22.4	77.6
All years	49.8	50.2

[1]Montana motor-vehicle-use study, 1963-1964.

study. In this study it was found that more than 90 percent of the 1963 and 1964 model vehicles were purchased new. The percentage of cars purchased new becomes less as year models get older. Only half of the cars bought as new were still operated by their original owner for more than 5 years. For all year models combined, half of the cars were purchased as new cars and half as used cars. The Illinois study also showed that about half of all passenger cars operated by residents of that state during 1957 and 1958 were purchased as new cars.

CLASS AND BODY TYPE

The cars in the sample from the Montana study were assigned by makes of cars to classes roughly indicative of weight (Table 6). Although a wide range of weights may exist in a given make, the authors believe that the classification was appropriate for the study purposes. Only a few vehicles were found in the sample for the class labeled "Other American" but it did not seem appropriate to put them into any other category.

Average odometer readings by class of car and major body type within each class are given in Table 7. The number of vehicles included in the sample and average age of the cars in each class are also given. The average age of the cars was included because the data have shown that age influences the miles traveled.

The data given in Table 7 show that the American compact class, representing more than 10 percent of all the sampled cars, had the lowest average odometer reading,

TABLE 6

PASSENGER CARS GROUPED IN CLASSES, ROUGHLY INDICATIVE OF WEIGHT[1]

American Compact[2]	American Light	American Light Medium	American Heavy Medium	American Heavy	Other American	Foreign
Comet	Chevrolet	Dodge	Buick	Cadillac	Corvette	Anglia
Corvair	Ford	Hudson	Chrysler	Continental	Thunderbird	Austin-Healey
Dart	Plymouth	Kaiser	De Soto	Imperial		Fiat
Falcon	Studebaker	Nash	Edsel	Lincoln		Hillman
Federal		Pontiac	Mercury			Jaguar
International Harvester			Oldsmobile			Mercedes Benz
Lark			Packard			Metro
Rambler						Opel
Tempest						Renault
Valiant						Triumph
Willys						Vauxhall
						Volkswagen
						Volvo

[1]Many vehicle makes not shown because none were found in sample.
[2]Some vehicles shown in this class may not be strictly compacts, but special purpose vehicles.

TABLE 7

AVERAGE ODOMETER READINGS BY CLASS OF CAR AND MAJOR BODY TYPE[1]

Class	Vehicles in Sample (No.)	Average Age (years)	Average Odometer Readings by Major Body Type (mi)			
			2-Door Sedans	4-Door Sedans	Station Wagons	All
American compacts	234	4.7	27,700	28,700	37,800	30,900
American light	1,174	7.3	56,500	47,100	49,700	50,300
American light medium	254	6.7	49,800	44,000	42,000	45,600
American heavy medium	469	6.7	48,100	46,000	46,800	46,600
American heavy	63	6.3	52,300	44,700	—	46,600
Other American	10	3.8	31,200	—	—	31,200
Foreign	74	4.9	31,500	67,400	48,500	37,900
All	2,278	6.7	49,200	45,000	46,200	46,400

[1]Montana motor-vehicle-use study, 1963-1964.

30,900 miles. The average is comparatively small primarily because of the relatively short history of the compact car as an advertised type so that there are few or no compact cars in the high-age groups. The American light class had the highest average odometer reading, 50,300 miles. In terms of body type for all classes of cars, the 4-door sedans had the lowest average odometer readings and 2-door sedans had the highest.

Another factor of interest in the usage of automobiles is the number of vehicles reporting average odometer readings of over 100,000 miles. In the Montana study it was found that about 5 percent of all the passenger cars surveyed had odometer readings of more than 100,000 miles. Table 8 gives the percentage distribution by broad year-model groupings and the average odometer reading in miles for each group. For vehicles showing a year model before 1950, the average odometer reading was 141,000 miles, representing 34 percent of these high odometer vehicles. Vehicles showing a year model between 1951 and 1955, representing 61 percent of all the high odometer vehicles, reported an average odometer reading of 115,000 miles. For all vehicles which had an odometer reading of over 100,000 miles, the average was 123,400 miles.

TABLE 8

PERCENTAGE DISTRIBUTION BY YEAR MODEL AND AVERAGE ODOMETER READINGS OF PASSENGER CARS REPORTING AVERAGE ODOMETER READINGS OF OVER 100,000 MILES[1]

Year Model[1]	Percentage Distribution	Average Odometer Readings (mi)
1945 and earlier	9.2	141,000
1946-1950	24.5	141,600
1951-1955	61.2	114,600
1956 and over	5.1	110,800
All years	100.0	123,400

[1]Montana motor-vehicle-use study, 1963-1964. The vehicles reported here represent about 5 percent of all vehicles reported on.

MULTICAR HOUSEHOLDS

The number of multicar households is increasing. In 1965, it was estimated that 20.6 percent of all households had more than one automobile as compared with 13.4 percent reported in 1960 (5). Multicar ownership is typically characteristic of suburban and rural dwellers rather than persons living in the closely built-up parts of cities where the ownership of even one car is a considerable burden. Tabulations of data reported in results of several studies indicate that the estimated total average annual mileage of travel for each of the cars in a multicar household is more than the average estimated for cars in the one-car households.

TABLE 9

ESTIMATED ANNUAL MILES TRAVELED PER PASSENGER CAR BY AGE OF VEHICLE CLASSIFIED BY ONE-CAR AND MULTICAR HOUSEHOLDS[1]

Age of Vehicles (years)[2]	Illinois Motor-Vehicle-Use Study		National Automobile Use Study	
	One-Car Households	Multicar Households	One-Car Households	Multicar Households
Under 1	12,300	14,300	12,400	13,600
1-2	12,800	13,900	11,600	13,400
2-3	11,200	13,600	10,400	10,800
3-4	11,500	11,000	10,100	10,500
4-5	9,600	8,900	9,000	10,400
5-6	9,100	8,800	8,700	9,400
6-7	8,400	6,800	8,600	8,800
7-8	8,400	7,500	8,400	7,100
8-9	7,100	7,500	7,800	7,500
9-10	6,600	7,200	6,100	6,600
10-11	6,000	4,000	5,100	6,400
11 and over	4,400	4,800	5,400	4,800
All years	9,900	10,000	8,900	9,300

[1]Estimated mileage for preceding 12 months.
[2]Each class interval includes lower, but not higher age than that shown.

Annual Miles of Travel

The estimated annual miles of travel by passenger cars classified by age and whether owned by a one-car or multicar household are given in Table 9. These figures are based on the National Automobile Use Study—the complete sample of 4,000 households was used—and the Illinois study. The Illinois study reported an estimated annual mileage of 9,900 miles for each car in the one-car households as compared with an average of 10,000 miles for each car in the multicar households. The national study reported an estimated annual average of 8,900 miles for each car in one-car households and 9,300 miles for each car in the multicar households.

Data published in the Chicago Area Transportation Study (CATS) in 1956 (6), tend to confirm the finding that drivers in multicar households drive more miles per car than those in single-car households. According to the CATS, it was estimated that internal trips for purely local purposes of cars of one-car households located within the study area aggregated 11.60 miles on an average weekday, whereas cars of multicar households were driven 12.38 miles on similar trips.

However, preliminary results from the 1963 to 1964 Montana study do not agree with previous findings. In the Montana study it was found that cars operated from multicar households averaged about 12 percent fewer annual miles per car than cars operated from single-car households. The single-car households estimated 9,100 annual miles of travel per car, two-car households estimated 8,000 annual miles of travel per car, and three-or-more-car households estimated 7,900 annual miles of travel per car. Although the Montana study findings seem to contradict the results of the other studies, several factors that might have influenced the findings should be considered. The fact that multicar households in Montana reported fewer average annual miles of travel per car than single-car households may reflect a different situation in multicar ownership in that state. It is possible that in Montana the second or older car on a farm or ranch is used primarily for utility purposes. In city or suburban areas of more densely populated states such as Illinois, the second car may be used for relatively more driving by the wife or one of the children. Data show that the average age of all cars in single-car households is 6.6 years in Montana, and 5.4 years in Illinois; in multicar households, 7.6 years in Montana, and 5.6 years in Illinois.

It is also possible that the results reported in the Montana study reflect a difference in the time the study was conducted; the Montana study was made in 1963 and 1964, the

TABLE 10

PERCENTAGE DISTRIBUTION OF PASSENGER CARS BY AGE OF CARS IN ONE-CAR HOUSEHOLDS AND BY AGE OF NEWER AND OTHER CAR(S) IN MULTICAR HOUSEHOLDS[1]

Age of Vehicles (years)[2]	One-Car Households		Multicar Households			
			Newer Car		Other Car(s)[3]	
	Actual	Cumulative	Actual	Cumulative	Actual	Cumulative
Under 1	4.4	4.4	10.0	10.0	0.5	0.5
1-2	14.2	18.6	22.6	32.6	4.0	4.5
2-3	14.5	33.1	17.3	49.9	4.7	9.2
3-4	14.1	47.2	17.2	67.1	8.3	17.5
4-5	9.9	57.1	9.4	76.5	8.5	26.0
5-6	10.5	67.6	9.0	85.5	12.4	38.4
6-7	7.1	74.7	5.0	90.5	7.4	45.8
7-8	7.8	82.5	4.9	95.4	12.9	58.7
8-9	7.1	89.6	2.5	97.9	14.6	73.3
9-10	5.0	94.6	1.3	99.2	11.7	85.0
10-11	2.4	97.0	0.2	99.4	6.4	91.4
11-12	1.4	98.4	0.1	99.5	3.1	94.5
12 and over	1.6	100.0	0.5	100.0	5.5	100.0
Total	100.0	—	100.0	—	100.0	—
Average age of all vehicles	5.4 years		5.6 years			

[1]Illinois motor-vehicle-use study, 1957-1958.
[2]Each class interval includes lower, but not higher age than that shown.
[3]Includes those vehicles in households with more than two cars.

national study in 1961, and the Illinois study in 1957 and 1958. The Montana data might possibly reflect a future situation. Other considerations that might have influenced the average number of miles driven by residents of single-car and multicar households include household composition, i.e., the number of persons of driving age, as well as income and availability of public transportation.

Another factor possibly associated with estimated annual travel by cars in single-car and multicar households is the distribution of cars by age. Table 10, which is based on the Illinois study, shows these distributions.

By comparing the age of cars in one-car households with the age of the newer cars in multicar households, it was noted that a higher percentage of newer vehicles were reported in the multicar households. Thirty-three percent of all cars owned by one-car households were less than 3 years old and 50 percent of the newer cars owned by

TABLE 11

RELATIVE DIFFERENCE OF AGES OF FIRST AND SECOND CARS OWNED IN TWO-CAR HOUSEHOLDS[1]

Year Model	Percentage Difference in Age in Years for Second Car					
	0-1 Years	2-3 Years	4-5 Years	6-7 Years	8 or More Years	All Years
1958	19	26	19	16	20	100
1957	22	25	21	20	12	100
1956	22	28	22	18	10	100
1955	23	24	31	14	8	100
1954	22	20	30	19	9	100
1953 and over	33	34	18	5	10	100
All years	24	27	23	15	11	100

[1]Illinois motor-vehicle-use study, 1957-1958.

multicar households were less than 3 years old. It appears that a high proportion of other cars in the multicar households were older vehicles. Almost 75 percent of the other or older car(s) in multicar households were 5 years old or older. One possible reason for this is that when a one-car household decides to buy a new car, often the trade-in dollar value is low and, logically or illogically, the family becomes a multicar household. Typically, one car is still used for work trips and shopping trips while the other car is used for trips generated by other family members during the entire day because a car is available. The new car is often used for the longer trips made on weekends and vacations. The average age of all vehicles found in one-car households was 5.4 years as compared with 5.6 years for all vehicles found in multicar households.

A further analysis was made of the data from the Illinois study to find out more about the characteristics of two-car households. Table 11 shows the relative ages of first and second cars owned in multicar households. Generally, this table shows that for the two-car households, the older car was less than one year older than the new car in one quartile of the households, 2 to 3 years older in the second quartile, and 4 to 5 years older in the third quartile.

SUMMARY

Some of the major findings covered in this paper that may be helpful in forecasting automobile travel are:

1. Based on actual odometer readings taken in April 1961 and June 1962, and estimated for 12 months, the annual travel per vehicle averaged over 11,000 miles for vehicles less than 3 years old, 9,500 miles for vehicles 4 and 5 years old, and decreasing year by year at an accelerated rate to 4,500 miles for vehicles over 12 years old.
2. The average odometer reading by age of car was 12,000 miles for vehicles one to 2 years old, 22,000 miles for vehicles 2 to 3 years old, 52,000 miles for cars 6 to 7 years old, and over 70,000 miles for cars 9 to 10 years old.
3. The average odometer reading by year model for passenger cars bought as new cars was less than the average odometer reading for the same year model for cars bought as used cars. Further, only 50 percent of the cars over 5 years old were being operated by their original owner.
4. The average odometer reading for American compact cars was 30,900 miles, the lowest of any class of car because of their lower average age. Foreign cars showed averaged odometer readings of 37,000 miles. All other classes of cars reported average odometer readings of over 45,600 miles with the American light cars reporting the highest average odometer reading of 50,300 miles.
5. Of over 2,300 vehicles found in households sampled in Montana during 1963-1964, 5 percent reported odometer readings in excess of 100,000 miles.
6. Two separate investigations disclosed that the estimated average annual miles per passenger car in single-car households was somewhat less than the estimated average annual miles per car in multicar households. The first investigation indicated that cars of single-car households averaged 9,900 miles a year, whereas cars of multicar households averaged 10,000 miles per car a year. Although these differences are not great, the results were confirmed by a second investigation which indicated that cars of single-car households averaged 8,900 miles a year, whereas cars located in multicar households averaged 9,300 miles per year. Preliminary results from a more recent study conducted in Montana indicate that vehicles driven from multicar households average fewer annual miles per vehicle than vehicles operated from single-car households.

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Consumer Preference in Transportation

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The objective of this study is to identify the characteristics of an ideal transportation system as conceived by the consumer. The results are based on a sample survey (550 individual interviews) in the Baltimore metropolitan area and selected adjacent rural areas.

The study is based on individual consumer attitudes and motivation rather than on consumer travel performance (the basis of OD and other travel mode analyses). It also measures the relative importance of influencing modal choice in scalar terms.

IN the last decade several hundred urban area OD-land-use studies have been conducted. From these, plans have been developed based on empirical relationships of travel demand, utilizing such variables as income, cost, residence, land use, and trip purpose. The forecasting of modal choice has been based almost solely on such aggregate travel characteristics. Yet, a review of the literature reveals that relatively little is known about the why of transportation consumer behavior.

For example, all studies have compiled information concerning such facets as the total number of trips taken in a particular area at a certain time, the general purpose of these trips, the mode of travel used, and some of the variables shown to be related to modal choices, e.g., income level, car ownership, land use, and population densities. These data describe consumer activities in detail, but little was learned about the reasons for these activities. There is a scarcity of information concerning the factors that affect consumer behavior in transport, the relative importance of these factors, and the effect of varying trip circumstances on them.

Some progress beyond the above situation is reflected in recent studies made by the Stanford Research Institute (1) and the University of Michigan Survey Research Center (2) into the value of travel time, the importance of cost in transport decisions, and the effect of transportation on consumers' housing location decisions.

The Stanford Research Institute study, for instance, attempts to quantify the importance of travel time for automobile users. Results obtained in preliminary studies to date, however, suggest that route choice cannot be predicted with a high degree of accuracy by using a single variable such as travel time. Decisions of this nature are most likely a function of the existing total need structure of individual decision-makers, and these decisions are likely to vary considerably from time to time for the same individual as his needs fluctuate. It is also likely that the variables which influence his decisions will differ in their importance as the purpose changes.

The Michigan study suggests, perhaps predictably in our affluent society, that the pecuniary cost of alternative transportation modes relative to other factors appears comparatively unimportant for most travelers. A study conducted in Boston (3) found such factors as cost, convenience, comfort, status, parking, flexibility, and traffic and congestion to be among the more important factors in modal choice.

A central problem in modal choice research is illustrated by these studies, i.e., the lack of aggrement concerning the definition and saliency of factors.

The University of Michigan study cites the following in their discussion of modal choice factors: frequency of service, whether have to change vehicles, flow of traffic

Paper sponsored by Committee on Economic Forecasting and presented at the 46th Annual Meeting.

(stop-starts or moves right along), fastness—speed, convenience, expense, comfort, distance, and crowdedness.

The Stanford Research Institute study considered these factors: tension (fatigue), sense of freedom (escape from routine), challenge (feeling of mastery control), safety, urgency, distance, operating cost, scenery, travel time, stop signs, traffic, and ease of driving (light traffic, few stop lights or signs, no cross traffic).

The study undertaken in Boston resulted in the emergence of the following factors: cost, convenience, comfort, status, traffic and congestion, parking, need to own an automobile, availability of public transportation, flexibility, and weather.

Two conclusions are evident from these studies. First, although there is some similarity among the various lists, there is a marked difference of opinion concerning the most important attributes. Second, differences exist regarding the terminology and apparent connotations attached to various attributes.

In the three studies cited, several factors were assumed to exist, and data were collected about them. The University of Maryland study differs in its approach. It did not begin with a predetermined set of factors, but rather factors emerged through mathematical factor analysis of respondent ranking of the importance of 44 transport characteristic items (questions).

THE STUDY OF CONSUMER DEMAND FOR TRANSPORTATION

The broad objectives of the research effort under way at Maryland are (a) to identify and assess the importance of attributes of an ideal transport system as conceived by the consumer, and (b) to determine the extent to which consumers consider existing systems to satisfy this ideal. This paper reports on a pilot study conducted in Baltimore and directed toward the first objective.

The answers to 5 specific questions were sought. They are the first part of a 10-question general design for the total research effort. Answers to these 5 questions are necessary before it is possible to move to the second 5. The questions are:

1. What are the most important trip purposes for which consumers have different preferences for attributes of transport modes?
2. What attributes do consumers regard as salient in typical recent trips?
3. What is the relative importance of the attributes for each trip purpose?
4. What is the perceived relative importance of the attributes for all trip purposes (i.e., of an overall ideal system)?
5. To what extent, and how, are demographic and specific trip characteristics of respondents related to perceived importance of trip mode attributes?

Answers to the last 5 questions are now being sought in another study that compares consumers' satisfaction with their importance rating. These questions are:

1. To what extent do consumers perceive themselves as being satisfied with the attributes of commonly used and available modes?
2. What is the relative frequency of use of existing modes for each trip purpose?
3. How available are the alternative modes for each trip purpose?
4. How do existing modes compare to the ideal generally, and for each trip purpose?
5. To what extent, and how, are demographic characteristics of respondents and trip characteristics related to periodical satisfaction of trip method attributes?

METHODOLOGY

The Maryland study had several objectives. First, a determination of the usefulness of the questionnaire as an information gathering device had to be made. Second, it was necessary to make some generalizations about the importance of criteria for consumer modal decisions in the test area. Finally, the questionnaire had to be perfected for eventual general application on a larger scale. The sample used in this study reflects these objectives.

To assure adequacy of the instrument for larger scale application, both urban and rural areas were included. Thus, an opportunity was provided to identify significant differences between attitudes of urban and non-urban transportation consumers.

Two sampling universes were, therefore, required. One consisted of the Baltimore area. This sample of 300 households included the City of Baltimore and parts of surrounding Baltimore, Anne Arundel, and Howard Counties. The second included that portion of Baltimore County outside the urbanized area and consisted of 50 households.

The total sample of 350 households resulted in the completion of approximately 550 individual personal interviews. The interviewer provided assistance when needed and filled in some demographic data sections of the questionnaire. But for the most part, the questionnaire was selfadministered.

A psychologically-oriented statistical technique of factor analysis was used for the examination of the collected data. Factor analysis is a method of reducing a large set of variables to a smaller set through an analysis of the linear correlations among the original variables. The set of factors which results from the analysis incorporates most of the characteristics and information of the original variables, and thus gives a parsimonious, yet comprehensive, summary of the original data.

The sample contained a larger proportion of women and high-income households in comparison with relevant data of the 1960 Census of Population. Keeping these limitations in mind, and the tentative nature of findings of a small pilot study, the following points emerge.

FINDINGS

Trip Purposes

Respondents were asked to consider various attributes of travel in relation to four trip purposes: (a) to work or school, (b) in-town shopping-personal business, (c) in-town social-recreation, and (d) out-of-town social-recreation. Correlation and factor analysis results suggest that different trip purposes may not be as important a factor in affecting the perceptions of transport mode attributes by consumers as previously thought. The summary of importance of these attributes given in Table 1 suggests that, although absolute differences in the importance of attributes between trip purposes are quite frequent and large, the relative importance varies little. Most attributes were considered to be more important for the work trip and the out-of-town nonbusiness trips than for the in-town shopping, personal business, and social-recreation trips.

TABLE 1

SUMMARY OF IMPORTANCE OF FACTORS WITHIN EACH TRIP PURPOSE[a]

Factors	Trip Purpose			
	Work-School	Shopping-Personal Business	In-Town Social	Out-of-Town Social
No repairs	4.52(1)	4.19(1)	4.29(1)	4.42(1)
Reliability	4.07(2)	—	—	—
Travel time	4.01(3)	3.09(4)	2.95(6)	3.36(5)
Cost	3.49(4)	3.29(3)	3.29(4)	3.59(4)
Independence	3.28(5)	3.02(5)	3.06(5)	3.31(6)
Traffic	3.08(6)	2.73(7)	2.79(7)	3.14(8)
Age of vehicle	2.75(7)	2.68(8)	2.71(8)	3.18(7)
With friends	2.03(8)	2.86(6)	3.50(3)	4.02(2)
Diversion	—	2.03(9)	1.93(9)	2.72(9)
Comfort	—	3.48(2)	3.63(2)	—
Avoid annoyances	—	—	—	3.96(3)
	(highest possible score: 5.00)			

[a]Both the relative and absolute importance of the dimensions identified in the factor analysis for each trip purpose are summarized. Ranks are presented in parentheses and average importance is indicated on a 5-category interval scale (of no importance = 1, of little importance = 2, of some importance = 3, important = 4, and very important = 5). See Appendix Tables 2 through 5 for individual trip purpose analysis.

Attributes of Transport Modes

In factor analysis, six factors emerge with similar item composition for all four trip purposes: cost, travel time, independence of control, traffic, age of vehicle, and freedom from repairs.

Other factors: diversions, comfort, reliability, and avoidance of annoyances appeared in three or less trip purposes. Although some of the factors include variables which cannot be interpreted conclusively, many of them cluster in seemingly rational configurations.

Importance of Attributes by Trip Purpose

Table 1 suggests that the main differences in the importance ranking of factors between trip purposes were for the "travel time" and "ability to take along family and friends" dimensions. Travel time was regarded as significantly more important on the work trips than for other trip purposes, and ability to take along family and friends is much more important for the out-of-town and social-recreation trips. Although comfort was unimportant for the work and out-of-town trips, it appeared in the other two trip purposes. The avoidance of annoyances was the third most important factor on the out-of-town trip, but failed to emerge at all for the other trip purposes. The importance of particular items (as opposed to factors) also depends on the purpose of the trip. For example, ability to look at the scenery and not being crowded were more important for the out-of-town and in-town social-recreation trips.

Importance of Attributes for an Ideal System

Although there are absolute differences among the arithmetic means of factors across the trip purposes, the relative rankings of the factors for all trip purposes are similar. Thus, it may be feasible to talk about generalized ideal systems. Based on the findings of the study, the following list indicates the main attributes of such systems from most important to comparatively unimportant:

1. Reliability of destination achievement (probably reflecting both safety and time consideration);
2. Convenience and comfort (with emphasis on flexibility and ease of departure);
3. Travel time (but considerable difference depending on trip purpose);
4. Cost;
5. Independence of control (reflecting autonomy of individual in determining speed, routes, diversions, etc., during trip);
6. Traffic and congestion (probably reflecting annoyance and perhaps safety);
7. Social (reflecting concern about who is being or capable of being traveled with);
8. Age of vehicle (perhaps indicative of a status dimension); and
9. Diversions (with some understatement of the importance of the scenery attribute).

The most important findings concerning each of these attributes are the following factors.

Reliability of Destination Achievement—This factor is most important to respondents on the "to work" trip, which probably reflects the need for appearing on the job at a certain time of day. It is interesting to note that its importance increases to those: (a) with lower incomes, (b) with full-time jobs, (c) who are nonwhites, (d) who are employed and middle aged, and (e) who are non-owners of homes and automobiles.

Convenience and comfort—Waiting in lines and comfort of seats (in that order) were considered most important for the "to work" trip. Comfortable seats, although important for all trips, were considered most important for the out-of-town trip and greater relative importance was placed on not being crowded for the "in-town social-recreation trip" and "out-of-town nonbusiness trip" than for other trip purposes.

Travel Time—Even though travel time is considered important on the work trips, a considerably different picture emerges with regard to other trip purposes. In the latter case, the factors of freedom from repairs, comfort, and cost are considered more important. It should also be noticed that bus users placed greater importance on getting to their destinations in the shortest times and by the shortest distance than did private automobile users. It appears as though a well of dissatisfaction was tapped for bus riders.

Cost—The pattern and variation in responses for the cost items supports conclusions of other studies that people generally do not know what it does or reasonably should cost them to travel (or drive, since about 80 percent of the trips to work in the United States are made by automobile). It is clear that additional investigation is needed in this particular area. It would probably be a mistake to conclude, however, that cost is of little or no importance because consumers do not know their cost accurately. Any significant upward change in cost or decrease in quality (transportation is purchased as a package with cost being related to quality of service) of transportation would likely boost the relative importance of cost. It should also be noted that variable costs might be the only relevant consideration because many people already own an automobile for many reasons unrelated to cost of providing transportation.

Independence of Control—It is concluded that, although this factor was regarded as of some importance by many respondents for all trips, there was little consensus among demographic groups concerning the degree of its importance. For instance, females consider it to be less important than do males. It is apparently not as crucial in transport user decisions as several of the others.

Traffic and Congestion—Travelers in Baltimore are a long way from the point where they regard traffic congestion to be as significant as travel time, convenience, reliability, and cost. To the conclusion of the Michigan study (2, p. 4) that "It appears unlikely that inconvenience or distance to work will be a major deterrent to further outward migration," could be added that it also appears unlikely that the influence of traffic and congestion will impede the current preference for automobiles in the foreseeable future.

Social—Several items were designed to tap a social factor: ride with people who dress and act like your friends, be able to take along your family or a friend, and assist others. Being able to take along your family or a friend showed a marked trend in its importance across trip purposes. It was considered of little importance except for the out-of-town trip, when it was considered both absolutely and relatively important. The other two factors were of some importance, but not admitted and/or perceived as being of compelling importance in choice among transport alternatives.

Age of Vehicle—A difficulty in the measurement of such a status factor is an aversion by respondents to admit its influence on their decisions. Thus, items were selected which, hopefully, measured this dimension indirectly. The achievement of the goal may be questioned, and the low ranking of age of vehicle may be inaccurate. If this finding is accurate, however, an interesting implication may be that the tendency of American automobile buyers to trade up to a new car is due more to a concern about reliability of their existing vehicle than "keeping up with the Joneses" as is often hypothesized.

Diversions—Diversion items were generally regarded as least important among the factors measured. The only exception was for the scenery variable which was regarded as absolutely and relatively important for out-of-town trips.

RELATIONSHIPS BETWEEN DEMOGRAPHIC CHARACTERISTICS AND TRANSPORT ATTRIBUTES IMPORTANCE

Rational sets of differences in the perceived importance of transport attributes were found among respondents based on their particular demographic characteristics and circumstances. One such difference existed for the attribute "independence," which refers to the amount of freedom the respondent has or perceives in terms of speed, direction, and personal control of the vehicle. The importance of this factor tends to increase with a person's education, income, residence distance from the Central Business District and number of vehicles owned. Furthermore, people between 25 and 44 years of age, males, whites, homeowners, and those with full-time jobs also emphasize the independence attribute.

On the other hand, the importance of travel time and reliability is higher for those people with lower incomes, nonwhites, and those who do not have their own vehicles. Older people and those who live close to the CBD also regard travel time and reliability as important. These results show that the traits associated with a high importance for independence form a set of attributes for a group of people who are relatively affluent. It is well known that people place more importance on such factors, whether it be for transportation or other facets of life, as income levels rise well above the subsistence level. When we consider the increasing affluence of our population, and assuming a continuation of the trend, it is proper to expect the importance of the independence factor to increase in the future.

An expected result appeared with the attribute of cost. The importance of cost is greater for people with lower education, nonwhites, and those who did not own vehicles. Surprisingly, however, cost was not significantly more important for low-income people than for high-income people.

Finally, the transport attributes labeled "traffic," "diversions," and "ability to take along family or friends" had no significant variations in their perceived importance based on demographic characteristics. An individual's demographic characteristics are apparently irrelevant in determining his attitudes about traffic, congestion, and opportunity to be amused or divert his attention while traveling. That there is no significant relationship between attribute importance and such demographic characteristics as number of people in the household, number in the household under 16 years old, household status, and distance to a public transportation source is not surprising. It is difficult to identify any particular rationale for expecting a relationship for these variables.

ANSWERING THE QUESTION "WHY?"

Modal split models have been only moderately successful. Several studies have found that modal choice decisions appear to be more complex than generally thought. As few as two variables have been used (travel time and cost) to predict modal choice, and most models include only four to six variables. The development of valid prediction models for modal choice seems to rest on incorporating several factors into the prediction milieu, and the sensitivity of the model to the complex interrelationships existing among factors.

There have been a few other studies with objectives partially overlapping those of this study. However, most other research and the comprehensive transportation land-use studies have focused on what people do, and the demographic variables which are related to what they do. This study is unique in that it provides at least a partial basis for determining not only what people do and say, but also why they do it, by focusing on the fundamental question: "What are the transport attributes which should be investigated and how are they defined in the minds of the consumer?"

Previously, this question has necessarily been answered by the researchers themselves, based on their own or others' conceptualizations and hypotheses. The focus here has been not to begin with a restrictive predetermined set of factors, but to develop a pool of transport-characteristic variables to which responses have been subjected to the statistical tool of factor analysis. (Selectivity was, of course, used in developing the exhaustive pool of characteristics in the first place.) This technique permits interpretation of relationships based on how the respondent has structured his responses, and leads to formation of the underlying factors defining and classifying the attributes perceived by transport users to be independent and important.

The research approach and results of this preliminary study, and the current extension of the study which incorporates questions dealing with both the importance of transport mode attributes and the perceived satisfaction of respondents with alternative transport modes in terms of these same attributes, should lead to an improved understanding of the "Why" of mode choice.

ACKNOWLEDGMENT

This paper is based on a study, "User Determined Attributes of Ideal Transportation Systems," prepared by G. A. Brunner, S. J. Hille, A. N. Nash, F. T. Paine, R. E. Schellenberger, G. M. Smerk, and C. A. Taff of the Department of Business Administration, University of Maryland, for the U.S. Bureau of Public Roads.

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Appendix

TABLE 2

FACTOR LOADINGS AND COMMUNALITIES FOR TRIP PURPOSE ONE—WORK-SCHOOL[a]

	Item	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 8	Communalities	Mean Factor Importance Scales
Factor 1, traffic									
Avoid varying speed	41	0.66	0.22	0.03	0.08	0.13	0.15	0.60969	
Avoid fast moving vehicles	42	0.62	0.08	0.04	0.08	0.11	0.02	0.51830	
Travel one direction	39	0.58	0.14	0.14	0.06	0.09	0.14	0.62173	3.08
Avoid slow moving vehicles	40	0.55	0.18	0.18	0.07	0.05	0.21	0.64721	
Travel different route	25	0.39	0.15	0.001	0.16	0.16	0.11	0.45650	
Factor 2, independence of control									
Control speed—direction	8	0.22	0.78	0.03	0.02	0.05	0.01	0.68857	
Independent of anyone else	7	0.09	0.74	0.06	0.10	0.03	0.06	0.65839	
Travel own rate of speed	6	0.19	0.69	0.13	0.13	0.01	0.28	0.69473	3.28
Listen to radio	10	0.06	0.44	0.002	0.03	0.18	0.08	0.40247	
Stop when want	14	0.11	0.40	0.08	0.13	0.09	0.18	0.53122	
Factor 3, travel time									
Short time	43	0.14	0.05	0.69	0.13	0.08	0.40	0.72869	4.01
Short distance	44	0.11	0.03	0.69	0.07	0.17	0.31	0.69225	
Factor 4, cost									
10 cents per mile	13	0.11	0.18	0.06	0.81	0.14	0.13	0.75889	
5 cents per mile	4	0.12	0.01	0.05	0.70	0.20	0.10	0.72618	3.49
25 cents per mile	29	0.04	0.10	0.01	0.70	0.06	0.14	0.65847	
Low in cost	32	0.07	0.04	0.28	0.48	0.11	0.26	0.56606	
Factor 5, age of vehicle									
Avoid old vehicle	22	0.19	0.09	0.13	0.02	0.72	0.14	0.63698	
Travel modern vehicle	18	0.11	0.08	0.05	0.20	0.66	0.12	0.62454	2.75
Avoid walking more than a block	21	0.09	0.01	0.13	0.35	0.38	0.28	0.59210	
Factor 8, reliability									
Leave when want to	3	0.02	0.15	0.03	0.12	0.13	0.64	0.53898	
On time	33	0.09	0.06	0.22	0.13	0.02	0.59	0.52201	
Convenient	34	0.10	0.05	0.19	0.07	0.11	0.58	0.54808	
Get there fast	1	0.06	0.01	0.16	0.08	0.13	0.54	0.51915	4.07
No repairs	35	0.27	0.19	0.14	0.16	0.16	0.49	0.53947	
Bad weather	37	0.21	0.08	0.17	0.15	0.10	0.48	0.55340	
Short time	43	0.14	0.05	0.69	0.13	0.08	0.40	0.72869	

[a]Only those people in the sample who answered every item in trip purpose one are included in this factor-analysis summary.

TABLE 3

FACTOR LOADINGS AND COMMUNALITIES FOR TRIP PURPOSE TWO—SHOPPING-PERSONAL BUSINESS

	Item	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Communalities	Mean Factor Importance Scales
Factor 1, traffic										
Travel one direction	39	0.65	0.12	0.13	0.03	0.08	0.10	0.08	0.54215	
Avoid varying speed	41	0.65	0.10	0.05	0.06	0.07	0.33	0.06	0.59144	
Avoid fast moving vehicles	42	0.62	0.05	0.01	0.07	0.01	0.04	0.07	0.53353	2.73
Avoid slow moving vehicles	40	0.56	0.13	0.27	0.06	0.04	0.29	0.10	0.58312	
Bad weather	37	0.39	0.02	0.35	0.39	0.15	0.07	0.29	0.53455	
Factor 2, independence of control										
Control speed—direction	8	0.12	0.74	0.07	0.02	0.02	0.06	0.05	0.58506	
Independent of anyone else	7	0.05	0.72	0.01	0.10	0.02	0.07	0.16	0.58272	3.02
Travel own rate of speed	6	0.11	0.62	0.22	0.10	0.04	0.10	0.07	0.53256	
Factor 3, travel time										
Short time	43	0.15	0.01	0.77	0.11	0.11	0.12	0.02	0.72187	
Short distance	44	0.11	0.04	0.75	0.10	0.04	0.15	0.003	0.70555	
On time	33	0.17	0.003	0.69	0.13	0.04	0.07	0.15	0.63486	
Convenient	34	0.12	0.04	0.64	0.15	0.12	0.01	0.19	0.5559	
Get there fast	1	0.07	0.03	0.57	0.07	0.12	0.15	0.07	0.53927	3.09
Leave when want to	3	0.02	0.14	0.57	0.05	0.05	0.10	0.12	0.53401	
Get ready easily	26	0.14	0.02	0.40	0.27	0.12	0.08	0.19	0.48264	
Avoid waiting	20	0.05	0.14	0.39	0.21	0.11	0.11	0.31	0.46248	
Avoid walking block or more	21	0.03	0.09	0.37	0.23	0.23	0.04	0.27	0.43572	
Avoid slow downs	24	0.32	0.10	0.36	0.11	0.17	0.33	0.02	0.48225	
Factor 4, cost										
10 cents per mile	13	0.04	0.14	0.18	0.71	0.07	0.05	0.17	0.63388	
25 cents per mile	29	0.02	0.10	0.10	0.70	0.01	0.05	0.004	0.60856	3.29
5 cents per mile	4	0.05	0.07	0.24	0.50	0.08	0.31	0.12	0.61516	
Low in cost	32	0.13	0.02	0.34	0.48	0.12	0.12	0.20	0.51783	
Factor 5, age of vehicle										
Avoid old vehicle	22	0.10	0.03	0.21	0.04	0.61	0.25	0.05	0.54947	2.68
Travel modern vehicle	18	0.07	0.01	0.23	0.15	0.53	0.37	0.14	0.55132	
Factor 6, diversions										
Keep busy	31	0.04	0.03	0.08	0.002	0.07	0.71	0.03	0.55206	
Travel different route	25	0.13	0.12	0.13	0.08	0.07	0.63	0.05	0.55856	
Eat or sleep	17	0.09	0.09	0.03	0.04	0.03	0.62	0.09	0.49944	
Move around inside	27	0.19	0.04	0.09	0.13	0.03	0.58	0.004	0.49770	2.03
Scenery	23	0.08	0.01	0.24	0.14	0.20	0.52	0.07	0.50562	
Act and dress like friends	19	0.16	0.10	0.03	0.02	0.25	0.43	0.15	0.39321	
Travel modern vehicle	18	0.07	0.01	0.23	0.15	0.53	0.37	0.14	0.55132	
Take family or friends	2	0.03	0.14	0.11	0.02	0.05	0.37	0.02	0.38926	
Factor 7, comfort of traveler										
Protected—weather	9	0.01	0.16	0.22	0.17	0.06	0.06	0.59	0.47703	3.48
Not crowded	16	0.16	0.03	0.27	0.17	0.21	0.05	0.44	0.59081	

[a]Only those people in the sample who answered every item pertaining to trip purpose two are included in this factor-analysis summary.

TABLE 4

FACTOR LOADINGS AND COMMUNALITIES FOR TRIP PURPOSE THREE—SOCIAL-RECREATION[a]

	Item	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Communalities	Mean Factor Importance Scales
Factor 1, traffic										2.79
Avoid varying speed	41	0.73	0.10	0.04	0.08	0.09	0.05	0.03	0.58926	
Travel one direction	39	0.68	0.08	0.02	0.01	0.03	0.15	0.08	0.56340	
Avoid fast moving vehicles	42	0.65	0.07	0.04	0.05	0.07	0.15	0.02	0.56122	
Avoid slow moving vehicles	40	0.59	0.19	0.26	0.10	0.08	0.02	0.004	0.55828	
Factor 2, independence of control										3.06
Independent of anyone else	7	0.04	0.71	0.04	0.08	0.21	0.01	0.13	0.57315	
Control speed and direction	8	0.19	0.71	0.03	0.05	0.03	0.06	0.05	0.58058	
Travel own rate of speed	6	0.12	0.65	0.16	0.06	0.01	0.06	0.06	0.55740	
Stop when want	14	0.17	0.45	0.12	0.09	0.03	0.22	0.12	0.46338	
Listen to radio	10	0.07	0.37	0.26	0.01	0.10	0.22	0.01	0.45445	
Factor 3, travel time										2.95
Short time	43	0.04	0.01	0.83	0.09	0.07	0.10	0.08	0.75933	
Short distance	44	0.08	0.02	0.79	0.12	0.07	0.07	0.04	0.76936	
On time	33	0.18	0.04	0.62	0.11	0.08	0.09	0.21	0.56361	
Convenient	34	0.11	0.08	0.58	0.14	0.06	0.02	0.26	0.55351	
Get there fast	1	0.04	0.003	0.52	0.03	0.12	0.17	0.07	0.52948	
Leave when want to	3	0.04	0.19	0.49	0.08	0.10	0.07	0.18	0.53799	
Get ready easily	26	0.13	0.09	0.38	0.29	0.17	0.16	0.29	0.54747	
Factor 4, cost										3.29
25 cents per mile	29	0.07	0.15	0.03	0.73	0.01	0.01	0.02	0.60137	
10 cents per mile	13	0.05	0.12	0.13	0.73	0.08	0.11	0.22	0.66323	
5 cents per mile	4	0.09	0.05	0.16	0.60	0.10	0.25	0.12	0.60547	
Low in cost	32	0.14	0.02	0.32	0.54	0.14	0.12	0.23	0.59336	
Factor 5, age of vehicle										2.71
Avoid old vehicle	22	0.17	0.06	0.19	0.07	0.63	0.07	0.13	0.57641	
Travel modern vehicle	18	0.14	0.04	0.18	0.15	0.57	0.23	0.18	0.58366	
Factor 6, diversions										1.93
Keep busy	31	0.05	0.03	0.16	0.09	0.06	0.57	0.07	0.44314	
Eat or sleep	17	0.12	0.13	0.03	0.08	0.09	0.54	0.11	0.42981	
Move around inside	27	0.20	0.03	0.11	0.15	0.06	0.45	0.10	0.40712	
Different route	25	0.23	0.18	0.05	0.15	0.13	0.37	0.003	0.45032	
Factor 7, comfort of traveler										3.63
Not crowded	16	0.07	0.17	0.22	0.14	0.08	0.21	0.53	0.53129	
Protected—weather	9	0.01	0.11	0.21	0.21	0.09	0.12	0.52	0.46274	
Stay in same vehicle	12	0.10	0.18	0.17	0.18	0.14	0.04	0.46	0.50101	
Avoid waiting	20	0.09	0.12	0.28	0.21	0.22	0.09	0.37	0.45029	
Comfortable seats	30	0.16	0.06	0.27	0.26	0.19	0.08	0.36	0.53266	

[a]Only those people in the sample who answered every item pertaining to trip purpose three are included in this factor-analysis summary.

TABLE 5

FACTOR LOADINGS AND COMMUNALITIES FOR TRIP PURPOSE FOUR—OUT-OF-TOWN NONBUSINESS[a]

	Item	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 10	Communalities	Mean Factor Importance Scales
Factor 1, traffic										3.14
Avoid slow moving vehicles	40	0.66	0.13	0.27	0.05	0.08	0.18	0.004	0.60831	
Avoid varying speed	41	0.50	0.14	0.11	0.16	0.14	0.32	0.10	0.61478	
Avoid slow downs	24	0.49	0.07	0.26	0.05	0.10	0.18	0.20	0.55029	
Travel one direction	39	0.36	0.08	0.03	0.01	0.01	0.09	0.42	0.51728	
Factor 2, independence of control										3.31
Control speed and direction	8	0.09	0.75	0.01	0.04	0.02	0.02	0.01	0.58259	
Independent of anyone else	7	0.01	0.71	0.01	0.07	0.03	0.01	0.03	0.58593	
Travel own rate of speed	6	0.12	0.65	0.09	0.11	0.04	0.03	0.11	0.57553	
Factor 3, travel time										3.36
Short time	43	0.22	0.03	0.76	0.05	0.11	0.18	0.09	0.70583	
Short distance	44	0.08	0.09	0.73	0.05	0.10	0.07	0.16	0.67772	
Get there fast	1	0.09	0.08	0.48	0.10	0.11	0.16	0.06	0.51216	
On time	33	0.09	0.07	0.45	0.08	0.12	0.08	0.28	0.55410	
Convenient	34	0.17	0.01	0.42	0.13	0.06	0.09	0.33	0.47417	
Leave when want to	3	0.04	0.14	0.38	0.07	0.03	0.05	0.21	0.40393	
Factor 4, cost										3.59
10 cents per mile	13	0.09	0.08	0.12	0.71	0.17	0.12	0.11	0.62166	
5 cents per mile	4	0.02	0.10	0.05	0.63	0.06	0.21	0.14	0.58949	
25 cents per mile	29	0.06	0.13	0.02	0.63	0.0004	0.09	0.36	0.61916	
Low in cost	32	0.11	0.003	0.19	0.36	0.08	0.10	0.43	0.50359	
Factor 5, age of vehicle										3.18
Avoid old vehicle	22	0.04	0.06	0.13	0.10	0.58	0.11	0.16	0.44931	
Travel modern vehicle	18	0.10	0.01	0.15	0.13	0.56	0.18	0.14	0.46867	
Factor 6, diversions										2.72
Keep busy	31	0.08	0.06	0.11	0.12	0.15	0.63	0.12	0.51896	
Move around inside	27	0.13	0.004	0.11	0.14	0.003	0.61	0.09	0.49179	
Eat or sleep	17	0.11	0.04	0.11	0.09	0.29	0.52	0.003	0.49896	
Factor 10, avoidance of annoyances										3.96
Not crowded	16	0.09	0.10	0.02	0.01	0.11	0.01	0.68	0.60039	
No repairs	35	0.01	0.05	0.05	0.06	0.11	0.09	0.67	0.55629	
Bad weather	37	0.15	0.04	0.23	0.01	0.17	0.02	0.45	0.48470	
Get ready easily	26	0.05	0.01	0.24	0.16	0.11	0.03	0.45	0.45956	
Low in cost	32	0.11	0.003	0.19	0.36	0.08	0.10	0.43	0.50359	
Travel one direction	39	0.36	0.08	0.03	0.01	0.01	0.09	0.42	0.51728	
Ride with people who talk	38	0.002	0.01	0.14	0.02	0.11	0.06	0.40	0.39651	

[a]Only those people in the sample who answered every item pertaining to trip purpose four are included in this factor-analysis summary.

How People Perceive the Cost of the Journey to Work

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Two national sample surveys of people in metropolitan areas were conducted in 1963 and 1965 in which questions were asked about the cost of the journey to work. The questions concerned the cost both of methods actually used and methods available to people but not used. The results show that people are well aware of costs, which are directly associated with the journey to work, such as parking fees and fares paid to transit companies. To estimate the cost of the journey to work by auto, however, requires an allocation of costs to the purpose. Most people have not made an estimate of the cost. Their offhand estimates of the cost for fuel are unreasonably high. Most people who have estimated costs of transportation by auto do not include depreciation. In this respect people seem to be good economists since cars which are used for the journey to work usually would be kept even if not used for getting to work.

•COSTS as people perceive them are directly relevant to their behavior. In simple cases it is sometimes possible to assume that people know the precise relative cost of the alternatives open to them. However, the question of what is the cost of the journey to work, especially by automobile, is not easy to answer. It may be useful, therefore, to examine the question of how people themselves think about the subject.

Several basic questions arise in considering people's perceptions of the cost of the journey to work. The first question concerns opinions of the subject. How well developed in people's minds are estimates of the cost? Second, are the estimates which people do make reasonably accurate or do they seem distorted? A third question is of a different order: what items should be considered by an analyst in estimating the cost to people of the journey to work by automobile? In particular, should the cost of a trip by automobile be estimated on the basis of full average cost per mile or marginal cost per mile?

The data presented here are based on personal interviews with two cross sections of the population from metropolitan areas in the United States, excluding the New York area. A total of 824 interviews was taken in September and October 1963, and 748 interviews were taken in September and October 1965 (1). The approach to the cost of the journey to work differed in the two surveys. In the first, questions were designed to elicit information about people's own views of costs. In the second, a more structured approach was taken and people were asked for specific information believed relevant by the investigators.

THE COST OF AUTOMOBILE TRANSPORTATION

This section will seek to answer four questions. Have people estimated the cost of operating the vehicle? If so, how reasonable are their estimates? Which is the relevant

Paper sponsored by Committee on Urban Transportation of Persons (Costs) and presented at the 46th Annual Meeting.

TABLE 1

PERCENT OF WORKERS WHO ALWAYS DRIVE THAT HAVE ESTIMATED HOW MUCH IT COSTS PER DAY

Category	Percent
Have estimated	28
Have never estimated	72
Total	100
Number of journeys to work	277

The question was: Have you people ever estimated how much it costs per day for (worker) to drive to work?

cost, full cost or operating cost? Finally, how many people pay to park and do they know the cost of parking?

Respondents were asked directly if they had estimated the cost of driving to work. Only about 25 percent, according to their own report, had ever estimated this cost (Table 1). Note that Table 1 is restricted to people who were interviewed in person and who reported that they always drove to work. Most people, it appears, never bother to estimate what it costs to drive to work.

Despite the low percentage of the population who have estimated the cost of the journey to work, when asked about how much it costs to drive to work one-way, including gas, oil and any tolls, 9 of 10 respondents were able to give an estimate for their own journey, and 8 of 10 gave estimates for other family members' journeys (Table 2). It appears, then, that people do have some idea about the cost of driving to work.

Given that most people can estimate outlay for gas and oil, how reasonable are their estimates? In order to check, it is necessary to examine the estimates on a cost-per-mile basis. People were asked to report the number of miles from home to work. If reports of the distance to places of work are correct, the conversion from total cost to cost per mile can be an accurate description of what people perceive as the per-mile cost. To check the accuracy of the distance estimates, figures from the interviews were compared with estimates taken from maps. This check proved difficult to complete and was made for only 31 journeys by auto.

Interviewees were asked to name the two streets at the intersection nearest their homes and the two streets at the intersection nearest their places of work. These intersections were located on large maps. A principal difficulty was in obtaining maps with a large enough scale to show individual streets and which still covered enough territory to include both place of work and place of residence. A standard map measure consisting of a small wheel and a scale with an indicator showing the distance covered by the wheel was then used to estimate the distance between these intersections along what seemed to be the most reasonable route (Table 3).

TABLE 2

ESTIMATES OF THE COST OF THE DRIVE TO WORK, COUNTING GAS, OIL, AND ANY TOLLS
(Percentage Distribution of Journeys to Work Where Worker Always Drives, 1965 Survey)

Estimate	All	Respondent's Journey	Other Family Member's Journey
Estimate given	88	94	81
Less than 20 cents	21	23	19
20-29 cents	24	28	18
30-39 cents	16	15	16
40-49 cents	4	4	5
50-74 cents	14	15	14
75-99 cents	4	5	3
$1.00 or more	5	4	6
Estimate not given	12	6	19
Total	100	100	100
Number of journeys	485	253	232
Median	30 cents	28 cents	31 cents

The question was: About how much does it cost (worker) to drive to work one-way, including only gas and oil and any tolls he may have to pay?

TABLE 3

COMPARISON OF TWO ESTIMATES OF DISTANCE BETWEEN WORKERS' HOMES AND PLACES OF WORK
(Percentage Distribution)

Estimates From Interviews (mi)[a]	Estimates From Map (miles)												All	Estimates (No.)
	Less Than 1/2	1	2	3	4	5	6	7	8	9	16	18		
1	3	14				3							20	6
2			3		3	3							9	3
3						7							7	2
4				3	3	7							13	4
5				7									7	2
6							3	3				3	9	3
7						11		3					14	4
8														0
9										3			3	1
10							3	3		3			9	3
12									3				3	1
22											3		3	1
26											3		3	1
All	3	14	3	10	6	31	6	9	3	6	6	3	100	
Number of estimates	1	4	1	3	2	9	2	3	1	2	2	1		31

[a]The total of all cells adds to 100 percent.

Although the two independent estimates of distance varied considerably, there did not seem to be any systematic tendency for respondents on the average to either underestimate or overestimate the distance to work. Thus, for all distances the average (mean) calculated from respondents' reports and from map readings was nearly the same. The mean from respondents was 6.1 mi and from the map 5.7 mi. However, individuals' estimates of the cost of driving to work may often be too high or too low because they do not estimate the distance correctly.

There is some reason to believe that estimates of average cost per mile for all respondents are not seriously biased by inaccurate reports of distance. The dispersion of respondents' estimates of cost per mile is partly the result of errors in both directions and reports of distance. The distribution is given in Table 4.

TABLE 4

COMPARISON OF MAP ESTIMATES AND RESPONDENTS' ESTIMATES OF THE DISTANCE TO WORK
(Percentage Distribution, 1965 Survey)

Respondents' Estimate	Percent of Auto Journeys to Work
Higher	42
Same	29
Lower	29
Total	100
Number of journeys to work	31[a]
Mean distance from respondents' reports	6.1 miles
Mean distance from map readings	5.7 miles

[a]These journeys to work are those for which it was convenient to make the check indicated. They do not constitute a sample of all journeys to work.

TABLE 5

COST PER MILE OF THE JOURNEY TO WORK BY AUTO
(Percentage Distribution, 1965 Survey)

Cost Per Mile (cents)	Percent of Auto Journeys
1	1
2	9
3	14
4	12
5	9
6	7
7	3
8 or more	27
Not ascertained	18
Total	100
Number of journeys to work	600
Median cost per mile	5. 1 cents

The questions used to calculate this distribution were: How far is it from your home to (worker's) place of work? About how much would it cost (worker) to drive (ride) to work one-way, including only gas and oil and any tolls (he) might have to pay?

The distribution of per-mile costs is given in Table 5. Some of the estimates, which run as high as 8 cents or more, seem grossly in error. Average cost per mile for gas and oil from respondents' reports was 5.3 cents. In arriving at this estimate, estimates of more than 8 cents a mile were arbitrarily reduced to 8 cents, a procedure which removes the most extreme overestimates and also reduces the average (see Table 5). The median of the distribution, which is not influenced by the extreme deviations, is 5 cents.

Even 5 cents is unreasonably high. The Bureau of Public Roads' national figure for passenger vehicles is about 14.4 mi per gallon of fuel. Assuming an average cost of 32 cents a gallon, the per-mile cost of fuel for operating a vehicle would be 2.2 cents. Fuel consumption for the journey to work may well be somewhat higher than the overall national average. If the cost per mile is increased by 20 percent to make a rough allowance for this factor, the estimate becomes about 2.6 cents per mile. Even if the estimate of the price of gasoline is increased to 38 cents a gallon, total cost for fuel reaches only about 3.1 cents a mile. An additional two-tenths of a cent per mile for oil gives a total of 3.3 cents. If it can be correctly assumed that people did include only the cost of gas and oil as the question asked, then the average perceived cost of driving to work, 5.1 cents per mile, is half again as high as the actual cost. Moreover, as noted previously, there is no reason to believe that the average cost per mile is biased by respondents' distance estimates.

Should it be concluded that people have in their minds estimates of costs which are seriously in error? Perhaps it is more accurate to say that people actually have little idea of what it costs to drive their cars to work. As Table 1 indicated, few people have actually estimated the cost. When asked to guess, they can do so. When they do guess, they seem to guess high, at least their estimates of cost for gas and oil are high. Indeed, the estimate of 5 cents for gas and oil is about equal to an authoritative estimate of total operating cost including not only gas and oil, but also tires, maintenance and that part of depreciation associated with mileage. Hewes and Oglesby (4) estimate total operating cost at 3.7 to $4.\overline{3}$ cents at 30 mph or 5.2 to 5.4 cents at 60 mph, plus the cost of standing time, deceleration, and acceleration as conditions may require.

TABLE 6

PERCENT INCLUDING DEPRECIATION IN THEIR COST ESTIMATES OF THE JOURNEY TO WORK
(Percentage Distribution of People Who Said They Had Estimated the Cost, 1963 Survey)

Category	Percent
Depreciation included	33
Depreciation not included	58
Not ascertained	9
Total	100
Number of journeys to work	151

The questions were: How much would your estimate be of the cost per day? What does this figure include?

A major question concerning the cost of driving to work is whether the relevant cost is the operating cost or the full average cost of owning and maintaining the vehicle. In the 1963 survey, people who reported that they had already estimated how much it cost per day to drive to work were asked what they had included in their estimate. As given in Table 6, about one in three had inlcuded depreciation. Thus, on the surface it appears that most people do not consider full cost to be relevant.

TABLE 7

CARS USED MAINLY FOR JOURNEY TO WORK AND WHICH WOULD BE KEPT EVEN IF NOT USED TO GET TO WORK
(Percentage Distribution, 1965 Survey)

Category	First Car	Second Car	Third Car
Used mainly to get to work	41	46	36
Would be kept even if not used to get to work	38	35	10
Would not be kept for purposes other than getting to work	3	11	26
Used mainly for other purposes or has multiple uses	59	54	64
Total	100	100	100
Number of cars	615	261	39

The questions were: Is this car used mainly to get to work, or for shopping or what? (If to get to work) Would (you) still keep this car even if (you) didn't use it to get to work?

The 1965 survey approached this same question from a different viewpoint. If full cost is, in fact, the relevant concept, then cars used mainly to get to work would not be kept if they were no longer needed for this purpose. In the survey, people were asked a series of questions about each of their cars. These questions were recorded by the interviewer in columns headed first, second and third. This classification has been preserved in the tabulations. All second cars are necessarily owned by families with more than one car. Which of the cars owned by a two-car family is first, and which is second may be more or less arbitrary, or a matter of which is more valuable.

As given in Table 7, about 41 percent of all first cars are used mainly to get to work. Only 3 percent, however, would be sold if not used for the journey to work. Of the second cars, only 11 percent would not be kept. Of the third cars, only 26 percent would not be kept for purposes other than getting to work. From this information, it would appear that full cost is relevant only for a small minority of the population. People who would retain their cars anyway should consider only the marginal cost of driving to work in comparing the cost of getting to work by auto and by public transportation. It should

TABLE 8

MEAN ANNUAL MILEAGE BY CLASSIFICATION ACCORDING TO USE
(1965 Survey)

Auto Use	Mean Annual Mileage	
	First Car	Second Car
Used mainly to get to work	13,600	12,000
Would be kept even if not used to get to work	13,400 (198)	12,600 (70)
Would not be kept for purposes other than getting to work	15,800 (17)	10,400 (23)
Used mainly for other purposes or has multiple uses	10,100 (321)	8,400 (112)
All	11,600	10,000

Figures in parentheses are the number of cars in the cell. The question was: About how many miles a year do you people average on this car?

be remembered that a large majority of car-owning families own only one car. (In early 1965, 79 percent of all families in the country owned at least one car but only 24 percent owned more than one.) Ninety-seven percent would keep the first car regardless of the journey to work.

A way to check on the reasonableness of these results is to examine the average annual mileage of cars used for different purposes. Does the journey to work represent a large or a small fraction of annual mileage? It will be recalled that average distance to work is between 5 and 6 mi, or 10 to 12 mi roundtrip—roughly 2500 to 3000 mi in 250 working days. This estimate no doubt should be increased to allow for the fact that some people drive home for lunch, but presumably these tend to be people who live very close to their jobs so that the added mileage would be small. Total reported annual mileage is shown in Table 8. A distance of 3000 mi or so is not a large fraction of the average annual total of 11,600 mi for first cars or of the 10,000 miles for second cars in the metropolitan areas studied.

Closer examination of Table 8 shows that cars driven mainly to get to work are driven farther than those used mainly for other purposes. For first cars, the difference is between 10,100 and 13,600 mi or about 3500 mi on the average. For second cars, the difference is between 8400 and 12,000 mi or about 3600 mi. These estimates are roughly consistent with the estimate of somewhat more than 3000 mi a year on the average to drive to work and back (on the assumption that cars used to drive to work are driven about as much as other cars plus the mileage driven to and from work).

One would expect that cars which would not be kept if not used for the journey to work would be driven fewer miles per year than cars which would be kept even if not used for this purpose. Table 8 suggests the contrary. There is little difference in average number of miles per year between cars which would be kept and cars that would not be kept. The number of cars which would not be kept is so small, however, that these estimates are not reliable.

For most people marginal cost is appropriate rather than full average cost in deciding whether to drive to work. There are several reasons for coming to this conclusion. Most people who have estimated the cost do not count depreciation. Most cars would be kept even if not used for work. On the average, the journey to work accounts for only a quarter to a third of the annual mileage on cars that are driven to work. The mileage driven to work seems to be additional to what is needed for other trips.

Most people never have estimated the cost of driving to work. When asked to do so, they can, but they have a general tendency to exaggerate the cost of gasoline and oil. Generally, people who go to work by car are not concerned enough about the cost to make an effort to estimate it carefully.

To understand this, consider the way in which people actually pay the cost of automobile transportation. They pay for a car when they buy it (or when they pay the installments). They then use the car for all sorts of trips over a period of several years. They pay insurance and registration fees annually. Some maintenance and repair expenditures may be made at more or less regular intervals, whereas others occur sporadically. In any event, there is usually no direct connection between any particular use of a car and the expenses associated with operation. Even when a person fills his gasoline tank he usually uses the fuel for a variety of trips. As discussed previously, most cars used to drive to work are also used for other purposes. To allocate costs to the journey to work requires an effort which people usually do not make.

This reasoning does not apply, however, to any tolls or parking fees that people may pay in connection with the drive to work. It is possible that people may be influenced by these direct outlays associated with the trip to work. Very few people pay tolls on the way to work. Thus, the more important direct outlay is for parking fees.

Two questions arise immediately in connection with parking fees. Do people pay to park? Do they know the cost of parking? Table 9 shows that only 8 percent of auto journeys to work involve a parking fee. Nearly everyone seems to be aware of whether the worker, who may be a family member other than the respondent himself, must pay to park. People also seem to be well aware of the amounts workers in the family pay for parking. Respondents claim to know the parking fee for 88 percent of all auto journeys to work—for only 12 percent were no estimates obtained (Table 9, part B).

TABLE 9

PARKING FEES

A. Whether Worker Has to Pay to Park	Percent Who Go by Car
Always rides or does not keep car at work	16
Pays to park	8
Does not pay to park	76
Not ascertained whether pays to park	—[a]
Total	100
Number of journeys to work	648

B. Cost Per Day to Park	Percent Who Pay to Park
Fee given	88
Under 10 cents	8
10-19 cents	10
20-29 cents	10
30-39 cents	13
40-49 cents	4
50-74 cents	15
75-99 cents	13
$1.00 or more	15
Fee not ascertained	12
Total	100
Median parking fee	48 cents
Number of journeys to work	52

[a]Less than one-half of 1 percent.

The fees paid are substantial compared to the direct operating cost of an automobile. For a typical 5-mi journey, the actual operating cost, including all variable costs, at 5 cents a mile would be from 25 to 30 cents one way, or 50 to 60 cents round trip. The median parking fee is about 48 cents. Generally, the imposition of such a fee in a typical situation would double the direct cost of the journey to work.

People who always journey to work by common carrier but who could go by auto if they chose also appear to be well-informed about the presence of parking costs. Here reports were obtained for 93 percent of the journeys. Of these, 16 percent would include a parking fee (Table 10).

Do parking fees actually discourage people from driving to work? To answer this question at least tentatively, Table 11 compares the method of getting to work of those in a situation in which driving involves a parking fee with those in a situation where parking is free. Because the number of journeys is small, these figures must be interpreted cautiously. Table 11, however, does support the initial premise that outlays directly related to the journey to work may be more important in the minds of people than vehicle operating costs. The presence of parking fees appears to reduce the number of journeys always made by car by roughly 20 percent, from 92 to 70 percent. The 20 percent who appear to be influenced by parking fees do not switch entirely to common carrier. Well over half say they go by common carrier sometimes and by auto at other times. Twice as many workers who must pay parking fees always go by common carrier—13 percent compared

TABLE 10

PERCENT OF WORKERS WHO GO TO WORK BY COMMON CARRIER THAT WOULD HAVE TO PAY PARKING FEES IF THEY SWITCHED TO AUTO
(Percentage Distribution, 1965 Survey)

Category	Percent
Would have to pay to park	16
Would not have to pay to park	63
Not ascertained	7
Would not keep car at work	14
Total	100
Number of journeys to work	51

TABLE 11

MODE USED IF WORKER MUST PAY TO PARK
(Percentage Distribution of Journeys for Which the Worker Can Go by Automobile and the Car Would Be Kept at Work, 1965 Survey)[a]

Mode Actually Used	All	Whether Pays or Would Have to Pay to Park	
		Yes	No
Always by car	89	70	92
Sometimes by car, sometimes by common carrier	4	17	2
Always by common carrier	7	13	6
Total	100	100	100
Number of journeys to work	586	60	526

[a]This table eliminates people who would not keep the car at work.

to only 6 percent of workers who did not pay parking fees. Parking fees appear to have a considerable effect on choice of mode.

A word of caution should be added about this result. Parking fees may be charged in congested areas in urban centers where common carrier service is well developed. People may ride the common carriers because of the service. The results in Table 11, in other words, may be to a greater or lesser extent a reflection of the existence of alternatives to the auto rather than, as appears, the effect of parking fees alone.

In summary, few journeys to work involve a parking fee. People are well aware of those that do and seem to know the cost. Parking fees do appear to induce some people to travel by common carrier rather than auto. The percent of journeys always made by car drops rather dramatically (by about 20 percent) when the worker with a choice of modes must pay a parking fee, but so few journeys involve a parking charge that the shift, in absolute terms, is small.

There has been considerable discussion of the possibility of using parking fees as a means of influencing people to go to work by common carrier. Whether such a policy would be desirable is a question beyond the scope of this paper. The findings presented do indicate that parking fees could be used to discourage driving.

THE COST OF PUBLIC TRANSPORTATION

Up to this point the main concern has been with the perceived cost of auto transportation. This section concerns the cost of public transportation. On the basis of the preceding analysis one would suppose that people would be reasonably well informed about common carrier fares. A fare is similar to a parking fee in that it is paid in cash and is directly and obviously associated with a particular journey.

From the viewpoint of the researcher, however, it is not easy to say whether people who do not go to work by common carrier but could do so are informed about fares. The difficult problem is to define who the people are who could go to work by common carrier. In this paper people's own reports are taken for information as to whether they have common carrier service available.

Respondents were able to report fares for about 78 percent of all journeys where, according to the respondent, the worker uses the common carrier or could if he chose (Table 12). As one would expect, fares were more often reported for journeys actually made by common carrier than for those where common carrier service, though available, was not used by the worker (93 percent for users as opposed to 73 percent for non-users). There were not enough journeys by common carrier in the sample to permit separate tabulation of respondents' reports for their own journeys to work. If reports by wives for husbands and vice versa could be eliminated, presumably 100 percent of users could report fares.

TABLE 12

ONE-WAY COMMON CARRIER FARE REPORTED BY WORKERS WITH AVAILABLE COMMON CARRIER SERVICE
(Percentage Distribution of Workers Who Report Availability of Common Carrier Service for Their Journey to Work, 1965 Survey)

One-Way Fare	All	Uses Available Service	Does Not Use Available Service
Fare reported	78	93	73
Less than 20 cents	4	4	4
20-29 cents	43	44	43
30-39 cents	21	30	17
40-49 cents	3	2	3
50-74 cents	4	7	3
75-99 cents	2	4	2
$1.00 or more	1	2	1
Fare not reported	22	7	27
Total	100	100	100
Number of journeys	205	55	150

To check the accuracy of peoples' reports about the journey to work, reports were obtained from local transit companies about journeys to work of heads of households. Information supplied to the transit companies included the names of the streets at the nearest intersection to the worker's home and at the nearest intersection to his place of work. They were also given the worker's time of arrival at work. The transit companies were asked whether there was service available for each journey that would get the worker to work at the stated time and if so, how much a one-way fare would cost. Information was obtained on 82 percent of the journeys to work for which information was requested from the transit companies. The number of reports asked for from each company was small because the survey was originally made in 32 metropolitan areas. There was a tendency on the part of some of the companies to regard the sample as inadequate as a sample of their own area. This criticism misses the point that the sample was designed to represent the 32 areas collectively rather than each individually. A more complete account of this project will be found elsewhere (2, Appendix A).

Among the items of information obtained from the transit company was the fare which they would charge for each specific journey to work. It is possible, therefore, to compare data from the interviews with information from the companies. This comparison is given in Table 13 for journeys actually made by common carrier and in Table 15 for

TABLE 13

COMPARISON OF REPORTS OF FARES FROM INTERVIEWS AND FROM TRANSIT COMPANIES FOR JOURNEYS MADE BY COMMON CARRIER
(Percentage Distribution, 1965 Survey)

Comparison	Percent of Journeys to Work of Heads of Families Who Use Common Carrier Service
Interview reports higher fare than transit company	17
Same fare from both reports	64
Interview reports lower fare than transit company	14
No estimate of fare in interview	5
Total	100
Number of journeys to work	36

TABLE 14

COMPARISON OF REPORTS OF FARES FROM INTERVIEWS AND FROM TRANSIT COMPANIES FOR JOURNEYS MADE BY COMMON CARRIER
(Percentage Distribution, 1965 Survey)

Company Fares (cents)	Fares From Interviews (cents)						All	Reports (No.)
	Less Than 20	20-29	30-39	40-49	50-74	75-99		
Less than 20	3						3	1
20-29	3	41	6			3	53	18
30-39		3	20	6		3	32	11
40-49			3				3	1
50-74				3	3		6	2
75-99			3				3	1
All	6	44	32	9	3	6	100	
Number of reports	2	15	11	3	1	2		34

TABLE 15

COMPARISON OF REPORTS OF FARES FROM INTERVIEWS AND FROM TRANSIT COMPANIES FOR JOURNEYS WHICH COULD HAVE BEEN MADE BY COMMON CARRIER BUT WERE NOT

Comparison	Percent of Journeys to Work of Heads of Families for Which Common Carrier Service Is Available But Is Not Used
Interview reports higher fare than transit company	18
Same fare from both reports	52
Interview reports lower fare than transit company	9
No estimate of fare in interview	21
Total	100
Number of journeys to work	98

TABLE 16

COMPARISON OF REPORTS OF FARES FROM INTERVIEWS AND FROM TRANSIT COMPANIES FOR JOURNEYS WHICH COULD HAVE BEEN MADE BY COMMON CARRIER BUT WERE NOT
(Percentage Distribution, 1965 Survey)

Company Fares (cents)	Fares From Interviews (cents)							All	Reports (No.)
	Less Than 20	20-29	30-39	40-49	50-74	75-99	$1.00 or More		
Less than 20	1	1						2	2
20-29	4	40	14					58	45
30-39		3	17	4	1			25	19
40-49			4	3				7	5
50-74				1	4	1	1	7	6
75-99						1		1	1
All	5	44	35	8	5	2	1	100	
Number of reports	4	34	27	6	4	2	1		78

journeys not made by common carrier, but which people themselves said could have been made by common carrier. It should be kept in mind that in the survey only one interview was taken per family and that the person interviewed was alternately designated as the head of the family or the wife of the head. Thus, about half of the reports about heads' journeys to work were made by wives.

As given in Tables 13, 14, 15 and 16, the accuracy of reporting is reasonably good for both common carrier users and nonusers. The reports for journeys actually made by public transit more often exactly coincide with the companies' reports. Even where the two do not coincide exactly the differences are small. Most people know the fare within a nickel or dime. Nonusers are more likely not to know the fare. About one out of five nonusers cannot give an estimate. Nevertheless, when common carrier service is available for the journey to work, most people know fairly accurately how much it costs.

THE RELATIVE COST OF AUTO AND PUBLIC TRANSPORTATION

In comparing the cost of getting to work by car and by common carrier, one way to proceed is by estimating the cost by each method and then comparing the estimates. Essentially it is this approach that has been followed in this discussion. An alternative is to approach the comparison directly. People who do not know the exact cost of getting

TABLE 17

OPINIONS AS TO WHETHER CAR OR COMMON CARRIER IS MORE EXPENSIVE
(Percentage Distribution of Journeys to Work for Which People Say There Is A Choice, 1963 Survey)

A. Whether Car or Common Carrier Is More Expensive	Percent of Journeys for Which There Is a Choice
Car is more expensive	38
Car and common carrier cost the same	25
Common carrier is more expensive	23
Not ascertained which is more expensive	14
Total	100
Number of journeys to work	198
B. Whether People Were Able to Estimate the Difference in Cost	**Percent of Journeys for Which People Thought One Mode Was More Expensive**
Could estimate difference in cost	40
Could not give an estimate of the difference	60
Total	100
Number of journeys to work	148
C. Estimated Differences in Cost Per Day	**Percent of Journeys for Which Cost Differences Were Given**
Less than 10 cents	5
10-19 cents	12
20-29 cents	12
30-49 cents	19
50-74 cents	30
75-99 cents	3
$1.00-$1.49	12
$1.50 or more	7
Total	100
Number of journeys to work	59
Median difference in cost	52 cents

The questions were: How does this trip by (common carrier) compare with going by car in terms of total cost? Do they cost the same or is one more expensive than the other? (If one more expensive) How much difference in cost is there?

to work by car may nevertheless have an opinion as to whether car or common carrier is the more expensive for their trip to work. Responses to the direct question about the comparison are given in Table 17. For 86 percent of the trips, respondents had some idea of the relative cost, whereas for 14 percent of the journeys no response was given. Thus, nearly everyone can give an opinion on this point if asked for one, just as nearly everyone who drives to work can make some sort of estimate of the cost of gas and oil. People say that common carrier and auto cost the same for about 25 percent of the journeys. Of the remaining 61 percent, 38 percent think car is the more expensive mode while only 23 percent hold the opposite opinion. Because people in general overestimate the cost of gas and oil for driving to work, it is not surprising that they tend to think of the automobile as the more expensive mode of travel.

Although people have opinions about which is the more expensive mode, for most people these notions are vague. For journeys deemed by the respondent to be more expensive by one mode than the other, a question was asked about the amount of the difference. Estimates of the cost differential were not obtained for 60 percent. Of the 40 percent who made estimates, over half estimated the cost differential to be more than 50 cents (Table 17, part C). Such cost differentials seem unreasonably high. They are impossible unless the 59 journeys included here all have some unusual characteristics. The general impression one gains from people's statements of relative costs of public and private transportation is that, though they may have ideas about the matter, these ideas are not based on careful calculations.

A measure of relative cost based on these estimates from the 1963 survey was included in a regression analysis of choice of mode for the journey to work which has been reported elsewhere (3). It had no value as a predictor. The conclusion indicated, from the evidence as a whole, that people do not have strong and well developed opinions about the relative cost of travel to work by car compared to public transportation.

SUMMARY

One conclusion is that most people are not trained cost accountants! They seem to be reasonably well aware of the prices of the goods and services which they buy, especially parking fees and the fares charged by transit companies. But to make close estimates of the cost of the journey to work by car requires allocation even of fuel costs, because a tank of gasoline can be used for a variety of purposes. People do not seem to be sufficiently motivated to make such estimates.

The uncertainty in their minds about true costs seems to lead people to overstate the cost of driving an automobile to work. Their estimates of fuel cost seem to be too high. People are well aware, however, of parking fees at work and some people seem to be influenced by them not to drive to work.

Those comparatively few people who have estimated the cost of driving to work usually do not include depreciation. In this way they seem to be correct since the journey to work accounts for only 25 to 30 percent of the annual mileage of cars which are driven to work, and because most people state that they would keep even their second and third cars regardless of whether they were used to get to work.

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An Empirical Method for Estimating Auto Commuting Costs

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•THE Port of New York Authority is engaged in continuous studies of the future adequacy of highway capacity across the Hudson River. The current program includes preliminary development of a computer model of trans-Hudson travel that encompasses 20 counties in the New York-New Jersey Metropolitan Region (Fig. 1) and virtually 100 percent of the originating points for selected trans-Hudson auto trips. As in other regional transportation studies, consideration must be made of vehicle operating costs incurred by the auto commuter.

The purpose of the present study is to determine if average auto operating costs vary by geographic areas within the study region. If variability occurs, is it sufficient to warrant use of separate operating costs for each area? The answer to this question appears important in the case of trans-Hudson commutation because trans-Hudson auto travel seems to imply relatively long travel distances as compared to typical auto commuting in other cities.

It is concluded that commuter auto costs may be estimated empirically on a county-by-county basis. The survey information required to increase the accuracy of the cost estimate is suggested. It also is shown that significant variability in vehicle-mile costs exists from county to county. Table 1 gives cost computations for trans-Hudson commuters. Table 3 shows car-mile costs. Appropriate sections of the text discuss the factors that affect the relative accuracy of individual data items in Table 1.

The variability of passenger-mile costs is less than the variability per car-mile. Therefore, the study recommends an out-of-pocket cost of 3.0 cents per passenger-mile for trans-Hudson commuter trips originating in the four most populous counties of New York City (New York, Kings, Queens and Bronx) and Hudson County, New Jersey. A cost of 2.7 cents is recommended for trips originating in all other counties. Comparable total costs per passenger-mile are 5.4 cents and 4.3 cents respectively. The costs developed in the study are presented on both an out-of-pocket and a total-cost basis to permit possible adjustments to an intermediate cost, if required on the basis of future studies of the relationship of cost to route selection. Table 3 also gives passenger-mile costs for the study.

The cost recommendations in this study are based on an analysis of auto commuting characteristics and costs for 1964. The procedure used to produce these costs is included in detail so that similar costs may be developed for other areas.[1] The year 1964 was selected because it was the base year for other studies related to the costs developed in this paper. The study shows a procedure for calculating total and out-of-pocket costs. Additional research is required to improve the input data and to ascertain the subjective attitude of the commuter toward auto costs. The use of average or typical data represents an attempt to summarize the many individual cases of high and low costs that come to the mind of the reader.

[1]For instance, see Table 25, "Automobile Operating Costs at Various Speeds," Chicago Area Transportation Study, Vol. 3, p. 126. Costs range from 3.69 cents per vehicle mile at 10 mph to 2.32 cents at 40 mph. The cost at 20 mph is 2.78 cents (1).

Paper sponsored by Committee on Urban Transportation of Persons (Costs) and presented at the 46th Annual Meeting.

Figure 1. Twenty-county study area and location of tunnels and bridges.

Table 1 gives the outline for the text that follows. The corresponding headings of Table 1 are used to begin each section. Thus, the next section of the text deals with the first group of data shown in Table 1—basic characteristics of auto travel. This includes discussion of commuting trip length, purchase costs and car life. The third section refers to the next group of data in Table 1. This group includes the computation of total annual costs per auto. Average total costs are based on the material discussed in the second section. The fourth section of the report discusses total costs and out-of-pocket costs per car-mile and per passenger-mile. The final section of the report summarizes the results of the study, suggests additional research, and offers several important conclusions in regard to the role of trans-Hudson auto commutation in the 20-county area.

BASIC AUTO TRAVEL CHARACTERISTICS

Commuting Trip Length

The most critical input to this study was the trans-Hudson commuter travel distance among the 20 selected counties. Therefore, trans-Hudson commuter trip length was computed first. Fortunately, the 1960 Census Journey-to-Work Study provided a matrix

TABLE 1

AUTO COSTS FOR TRANS-HUDSON COMMUTERS

Category	Trips Originating in New York Counties										Trips Originating in New Jersey Counties									
	New York	Queens	Kings	Bronx	Richmond	Nassau	Suffolk	Westchester	Rockland	Orange	Hudson	Essex	Union	Bergen	Passaic	Morris	Middlesex	Monmouth	Somerset	Mercer
Basic travel characteristics:																				
Commuting trip length	17	23	20	16	22	37	61	31	25	50	12	26	22	21	34	43	32	45	47	56
Commuting miles per year	8,200	11,000	9,600	7,700	10,600	17,800	29,000	14,900	12,000	24,000	5,800	12,500	10,600	10,100	16,300	20,600	15,400	21,600	22,600	26,900
Non-commuting miles	3,000	3,000	3,000	3,000	4,000	4,000	5,000	4,000	5,000	5,000	3,000	4,000	4,000	4,000	4,000	5,000	4,000	5,000	5,000	5,000
Total annual miles per car	11,200	14,000	12,600	10,700	14,600	21,800	34,300	18,900	17,000	29,000	8,000	16,500	14,600	14,100	20,300	25,600	19,400	26,600	27,600	31,900
Miles per gallon of gas	12	12	12	12	13	13	14	13	14	14	12	13	13	13	13	14	13	14	14	14
Cost per gallon of gas (cents)	37	37	37	37	37	35	35	35	35	35	33	33	33	33	33	33	33	33	33	33
Cost of car ($)	3,090	3,090	3,090	3,090	3,090	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000
Average life of car (yr)	8.0	8.0	8.0	8.0	8.5	6.0	3.8	6.9	7.6	4.5	8.0	7.9	8.5	8.5	6.4	5.1	6.7	4.9	4.7	4.1
Total annual costs ($):																				
Insurance	224	169	222	211	142	171	145	145	145	130	165	180	165	150	150	140	145	140	135	150
Registration and license	18	18	18	18	18	18	18	18	18	18	20	20	20	20	20	20	20	20	20	20
Depreciation	386	386	386	386	364	500	790	435	395	667	375	380	353	353	469	588	448	612	638	733
Maintenance	150	150	150	150	141	167	200	167	157	200	150	157	141	141	167	180	167	180	200	200
Tires	45	56	50	43	58	87	137	76	68	116	35	66	58	56	81	102	78	106	110	128
Gasoline	345	432	388	330	416	587	857	509	425	725	242	418	371	358	516	603	493	627	650	752
Total annual cost	1,168	1,211	1,214	1,138	1,139	1,510	2,147	1,350	1,208	1,856	987	1,221	1,108	1,078	1,403	1,633	1,351	1,685	1,753	1,983
Total cost per mile:																				
Cost per car-mile (cents)	10.4	8.7	9.7	10.6	7.8	6.9	6.3	7.1	7.1	6.4	11.2	7.4	7.6	7.6	6.9	6.4	7.0	6.3	6.4	6.2
Passengers per car—overall	1.9	1.8	1.9	1.9	1.8	1.7	1.5	1.7	1.6	1.5	1.9	1.7	1.8	1.8	1.7	1.5	1.5	1.5	1.5	1.5
Cost per passenger-mile (cents)	5.5	4.8	5.1	5.6	4.3	4.1	4.2	4.2	4.4	4.3	5.9	4.4	4.2	4.2	4.1	4.3	4.7	4.2	4.3	4.1
Out-of-pocket adjustments:																				
Total out-of-pocket cost ($)	540	638	588	523	615	841	1,194	752	650	1,041	427	641	570	555	764	885	738	913	960	1,080
Out-of-pocket cost per car-mile (cents)	4.8	4.6	4.7	4.9	4.2	3.9	3.5	4.0	3.8	3.6	4.9	3.9	3.9	3.9	3.8	3.5	3.8	3.4	3.5	3.4
Passengers per car—commuter	1.6	1.6	1.6	1.6	1.5	1.5	1.3	1.5	1.3	1.3	1.6	1.5	1.5	1.5	1.5	1.3	1.3	1.3	1.3	1.3
Cost per passenger-mile—commuter (cents)	3.0	2.9	2.9	3.1	2.8	2.6	2.7	2.7	2.9	2.8	3.1	2.6	2.6	2.6	2.5	2.7	2.9	2.6	2.7	2.6
Cost per trip—commuter ($)	0.51	0.67	0.58	0.50	0.62	0.96	1.65	0.84	0.72	1.40	0.37	0.68	0.57	0.55	0.85	1.16	0.93	1.17	1.27	1.45

of 74,547 auto commuting trips among 22 counties in the area, including counties used in the trans-Hudson studies (Appendix A). The large number of trips in Appendix A permits a reasonably accurate computation of trans-Hudson trip length by county of trip origin. A trip length for each origination county permits development of auto costs by county.

Lengths of commuting trips originating in each county were computed by summing the number of trips to the destination counties on the other side of the Hudson River. The percentage going to each county was multiplied by the mileage to that county as scaled from maps. The result was an average commuting trip length. The total annual commuting mileage was computed by expanding the mileage per one-way commuter trip by 240 work days per year. The product was multiplied by two in order to arrive at total commuter mileage in both directions.

Mileages for commuter trips were computed via the most convenient routes. The selected route determines whether the commuter uses the Tappan Zee Bridge, George Washington Bridge, Lincoln Tunnel, Holland Tunnel or Verrazano-Narrows Bridge. The distance between counties was measured from the population center of the originating county to the estimated employment center of the destination county. Resultant mileages were adjusted to reflect the discrepancies that occur between geographical centers and population centers in irregularly shaped counties. Trans-Hudson auto trips involved considerably longer distances, relatively fewer trips and no intra-county travel, as compared to more typical commuting patterns.

Non-Commuting Miles Per Vehicle

The total annual miles per vehicle includes both commuting miles and non-commuting miles. Appendix B shows that the average car in the United States travels 4,000 non-commuting miles per year. Extensive data were not available on local non-commuter miles in the New York-New Jersey area. Therefore, a pilot survey was undertaken at the 1000-car parking roof of the Port

Authority Bus Terminal in Manhattan. Odometer readings, point of origin and vehicle age were determined for recent model trans-Hudson commuter autos from the 10 New Jersey counties included in this study. Recent model cars were used to reduce the possibility of previous ownership by a person who was not a trans-Hudson commuter. Trip length was computed and annual commuter mileages were deducted from odometer readings. The residual mileage represented non-commuter travel. These data were adjusted to reflect the tendency for new cars to acquire a higher-than-average annual mileage. The adjusted mileage showed close correspondence to national data. Therefore, 4,000 non-commuter miles per year was used for most counties.

Physical barriers such as the Hudson River tend to limit recreational travel. The results of the pilot survey indicate that relatively congested street systems also limit local travel. Thus, non-commuter travel for cars used in daily commuting was set at only 3,000 miles per year in New York City and Hudson County. On the other hand, shopping centers and local recreational areas are scattered in the least densely populated counties. Non-commuter trips to these places add more annual miles than similar trips in New York City. Therefore, the cars used for commuting from counties with low densities were assigned 5,000 miles per year for non-commuter trips. Non-commuting mileage probably would be higher for the other car in a two-car family. However, this study only considers cars engaged in trans-Hudson commutation. More extensive local data on non-commuting mileage would be most helpful. A 1,000-mile variance in this figure leads to a 7 percent change in total mileage for a typical trans-Hudson commuter.

Costs Per Automobile

The cost per automobile is extremely difficult to determine. This study computed a base cost directly from dealer prices for 32 separate makes of automobiles, including imported cars (prices were obtained from local dealers in the New Jersey-New York Metropolitan Area). The price of the intermediate model of a four-door sedan was selected for determining cost. Approximately 5 percent was added to reflect the estimated distribution of sales among other models in the New York-New Jersey area, such as two-door sedans, two-door hardtops, and four-door station wagons.

Most car buyers also purchase various combinations of accessories. Therefore, additional costs were included for antifreeze, back-up lights, clock, mirrors, push-button radio, automatic transmission, windshield wipers and undercoating if these items were classified as extras. Eight-cylinder engines, power steering and power brake costs were included for larger models. Finally, a 15 percent dealer charge was added to the basic wholesale price. The result was an average basic consumer price of $2,900. The price computation and distribution of 1964 sales among the standard dealer classifications on a national basis is given in Table 2.

The basic 1964 price per vehicle was adjusted to reflect costs of financing, costs of ownership transfer and price increases over the life of the vehicle. Interest costs for financing auto purchases normally were considered part of annual operating costs during the term of the loan. No annual interest cost was included when the loan was repaid. However, this study wanted to establish an average interest cost for all cars. Therefore, the interest cost was added to the basic price. Subsequent division by average car life permits development of an average interest charge. This can be separated from depreciation costs if desired.

"Automobile Facts and Figures," published by the Automobile Manufacturers Association in Detroit, shows that 40 percent of new automobiles are sold for cash. The experience of New York City banks is that the remaining 60 percent are financed with a typical down payment of 20 percent of total cost to the purchaser. Thus, 48 percent of total dollar sales are financed through loans. A loan cost of $170 was added to the basic price, resulting in an adjusted price of $3,070.

The total car population was comprised of both new and used cars. "Automobile Facts and Figures" indicates that the typical vehicle has three owners. The used-car dealer and the private individual endeavor to resell their cars at a slight profit. The

TABLE 2

BASIC AVERAGE AUTO PURCHASE PRICE

1965 Make	Estimated Approximate Price ($)	Percent of Total Cars Sold	Contribution to Purchase Price ($)
All imports	2,200	8	176
American (Motors)	2,300	2	46
Chevy II, Falcon, Valiant	2,400	8	192
Barracuda, Mustang	2,500	4	100
Dart	2,600	3	78
Comet, Corvair, Tempest	2,700	8	216
Belvedere, Classic Fairlane	2,800	6	168
Chevrolet, Fury, F-85, Special	2,900	24	696
Ambassador, Chevelle, Coronet, Ford, Polara	3,000	18	540
Buick, Mercury, Pontiac, Riviera	3,300	10	330
Olds	3,400	4	136
Chrysler	3,600	2	72
Corvette, Thunderbird	3,800	1	38
Cadillac, Imperial, Lincoln	5,600	2	112
Estimated average purchase price		100	2,900

used-car dealer also must recover his operating costs. From the viewpoint of all car buyers, this profit represents an addition to the original new car price. Therefore, it must be depreciated over the life of the car just as the profit on a new car is depreciated. Discussions with dealers indicated that the average total cost to the buyer over and above the automobile's cost to the used-car dealer was $75 (average resale value of $750 times 10 percent). Then the average cost per car for two resales increased $150, reaching a total of $3,220.

Precise data were not available on average resale values. For instance, use of average depreciation over the entire life of the car implies relatively equal car usage each year. Depreciation costs would increase if the average age of cars owned by trans-Hudson commuters was less than the average age of all automobiles. On the other hand, depreciation costs would be less if trans-Hudson commuters favored used cars. However, the overall effect of this adjustment is small. An additional $150 would amount to about $15 per year in additional depreciation, as compared to total depreciation costs of about $500.

The third adjustment in the average automobile price reflects the increase in automobile prices from year to year. An average life of a car of 9 years, as derived from "Automobile Facts and Figures," was used as the base for this computation. The average age of all cars on the road normally is less than half of the average life. Cars in the study area were approximately 4 years old. The average price of $3,220 was decreased to reflect auto prices 4 years previously. Consumer price indices from 1960 through 1964 indicated a slight decline in new car prices. However, an auto price increase of 1.7 percent per year was used to reflect both the greatly increased price index for used cars and the tendency for auto owners to trade up in recent years. Therefore, a net reduction of 6.75 percent or $220 was made in the 1964 price. Thus, the average adjusted price per car was $3,000. Cars purchased in New York City were taxed at 3 percent or $90 in 1964. Tax costs were added to the adjusted price.

Average Life Per Car

The comparison of new passenger car registrations to total passenger car registrations is reported in various editions of "Automobile Facts and Figures." Division of average annual new car registrations into total annual registrations for the years selected yields average car life. An average of 8.4 years was computed for New York and 9.0 for New Jersey. The national average auto age was about 11 years. New York City data were not available. However, the area probably imposes relatively stringent demands on cars as compared to the rest of the state. Comparative observations indicate that many New York City drivers desire higher than average appearance standards. It also was apparent that local driving conditions required relatively high vehicle reliability. Therefore, an average life of only 8.0 years was used for automobiles in New York City. A maximum average life of 8.5 years was used for the surrounding counties.

Automobiles in the United States accumulate an average of 9,500 miles per year. Thus, a car that lasts 9 years would travel 85,500 miles. Again, it is important to note that the typical car useage pattern includes very high mileage during the first year of ownership and very low mileage near the end of the car's life. The 9,500 miles per year is an average for all years as well as all cars. Extensive investigation would be necessary to determine to what extent, if any, the trans-Hudson commuter deviated from this pattern. However, the effect on computations of average costs should be minimal.

The 9,500 miles per year was based on an average one-way commuter trip of 7.1 miles (Appendix B). Actually, most trans-Hudson commuter trips exceed 20 miles, and several exceed 30 miles. A vehicle used for commuting 30 miles a day in each direction plus 4,000 miles per year in recreational travel accumulates 156,000 miles in 8.5 years. On the other hand, reported personal auto mileages seldom reached 156,000. Commuter travel causes more vehicle wear than equal amounts of long distance trips and off-peak travel, suggesting a downward adjustment for trans-Hudson commuters. Therefore, a maximum average auto mileage of 130,000 was adopted for purposes of this study. This mileage, although high, was considered reasonable for the relatively small segment of auto commuters that drive excessive distances each day. (The 1960 Census Journey-to-Work Survey indicates that only 74,547 persons are trans-Hudson commuters out of a total of 2,843,873 persons whose auto commuting trip originates and terminates in the 20 selected counties.) Cars were depreciated over the period it takes to accumulate this mileage if it was less than 8.5 years.

TOTAL ANNUAL AUTO COSTS

Insurance

The estimate of annual insurance included costs for $20,000/$40,000 liability insurance, property damage insurance, comprehensive fire and theft insurance and $100 deductible collision insurance. Insurance rates reflected the length of commuting trips. Thus, $5 per year was added for every 5-mile increase in commuter trips, starting with trips over 5 miles in length and reaching a maximum of $25 additional for commuting trips that were 30 miles or longer. Insurance rates were adjusted to reflect a 10 percent reduction for the second car in a two-car family. Insurance rates were significantly higher for residents of New York City, as compared to residents of counties on the fringe of the metropolitan area.

Registration and License

The cost of vehicle registration and driver licensing varies between the two states. The 1964 annual cost of $18 for New York State included $17 for annual vehicle registration or 50 cents per 100 lb of vehicle weight plus one dollar as the annual cost of a driver's license.

Depreciation

Annual depreciation was computed by the straight-line method. That is, the total purchase cost of the vehicle was divided by the expected life of the vehicle.

Maintenance

Maintenance costs fall into three categories. The first includes changes of oil, oil filter replacements, motor tune-ups, lubrications, electrical system repairs, and inspections. These costs occur relatively frequently and constantly throughout the life of the car. The second category includes such routine maintenance and repair items as brake linings and batteries. These items need relatively infrequent but constant replacement over the life of the vehicle. Usually, they do not occur during the first 20,000 miles of vehicle life.

The final category includes heavy maintenance and repairs such as clutch replacement, muffler repair or a valve job. These costs are random in occurrence, causing large fluctuations in annual maintenance costs. More importantly, they tend to increase reapidly after the first 20,000 miles and gradually thereafter. At some point, poor motor operation and/or body deterioration discourage additional major repairs. After this time, major repairs are deferred. Finally, the car deteriorates beyond safe limits and it is junked.

The average amount of annual maintenance is the sum of these three component costs. It increases rapidly after the first 20,000 miles and gradually thereafter due to the influence of routine maintenance costs. Total maintenance reaches a peak around the fifth, sixth or seventh year as heavy repairs are required. Soon thereafter, repairs are no longer considered worthwhile and costs begin to decline slowly. Total maintenance depends on both mileage and vehicle age. The example pertains to a car that is retired after 9 years. Total maintenance costs, exclusive of tires, for cars that are retired at earlier ages experience similar but less expensive maintenance costs. Estimates are adopted from previous studies (2) as follows:

ESTIMATED MAINTENANCE COSTS

Automobile Retired at Age:	Total	Per Year
4 years	$ 800	$200
5 years	900	180
6 years	1,000	167
7 years	1,100	157
8 years	1,200	150
9 years	1,200	133

Tires

Tire costs vary directly with mileage. A cost of 0.4 cents per mile was used. This permited replacement of four tires at a cost of $25 each after 25,000 miles of travel. Car owners do not purchase tires during the first 25,000 miles of operation. The 0.4 cents per mile was allocated to purchase of snow tires during this period.

Gasoline

Gasoline costs vary directly with mileage and were included in all per mile estimates. Gasoline costs per mile included two components, the number of miles which an auto can travel on a gallon of gasoline and the cost per gallon. The 1965 edition of "Automobile Facts and Figures" presents both vehicle-miles andgallons sold for New York and New Jersey. The division of vehicle-miles by gallons sold resulted in an average of 14 miles per gallon.

The relatively congested highways in New York City produce relatively poor gas consumption due to inefficient operation, more speed changes and lower than optimum cruising speeds. These undesirable operating conditions suggest a downward adjustment to 12 miles per gallon for New York City trips and 13 miles per gallon for adjacent communities[2]. The cost per gallon of gasoline was for a regular or medium grade. An average cost of 33 cents per gallon was prevalent in New Jersey, 35 cents was typical for New York State and 37 cents was used for New York City.

Costs Not Included in Study

Parking costs and toll costs were not included in this study. The study also omits garage expenses, accident costs, time costs and interest costs not associated with financing new purchases. Garage expenses and other interest costs vary greatly depending on a person's means, residence and alternative investment opportunities. In-

[2]For instance, see "How Much Per Mile," Automotive Fleet, pp. 21-22. High gas consumption is common for cars that accumulate high mileage (3).

clusion of typical interest costs would add 6 percent per year to total auto costs. Some accident costs also are reflected in insurance rates. Other accident costs and all time costs deal with alternate routing and terminal considerations. These costs and attitudes were excluded from this particular study but are reflected in other Port Authority studies now under way. The effect of parking and toll costs are discussed in the conclusion.

TOTAL COSTS PER MILE AND OUT-OF-POCKET ADJUSTMENTS

Total Annual Cost and Cost Per Car-Mile

For the total cost computations, the full cost of the car was allocated to all trips, including those for commuting. Various literature in this field indicates that few auto owners consider all auto costs in computing costs for commutation trips. The last part of this section discusses the more commonly used out-of-pocket costs. The overall cost per car-mile equals the total annual costs divided by the total annual miles.

Passengers Per Car

Current trans-Hudson studies are concerned particularly with costs per passenger-mile. Auto occupancy data are required to convert costs per car-mile into costs per passenger-mile. The number of passengers per car depends on whether the trip is commutation or non-commutation. Commuter trips have fewer passengers per car than all trips. However, commuter trips in the study area have more persons than the typical commuter trip in other cities. The number of persons per commuter auto is obtained directly from continuous sampling surveys at trans-Hudson facilities. It is 1.5 persons as compared to the national average of 1.3.

National averages are used as the base for determining persons per car for other travel. However, the variation in occupancy for other travel is derived from the continuous sampling surveys. Persons per car are higher in New York City and lower in the suburban counties for both commuting and other travel. This study combines commuting and other persons per car into an overall auto occupancy to compute total commuter costs per passenger-mile. The data are as follows:

Type of Trip	Persons Per Vehicle	
	Typical	Range
Trans-Hudson commuter trips	1.5	1.3-1.6
Other trips by trans-Hudson commuters	2.5	2.3-2.7
All trips by trans-Hudson commuters	1.7	1.5-1.9

Cost Per Passenger-Mile

The overall cost per passenger-mile was computed by dividing persons per car into overall costs per car-mile.

Total Out-of-Pocket Cost and Out-of-Pocket Cost Per Car-Mile

This study focuses on the out-of-pocket portion of auto costs in computing costs for commutation trips. However, future trans-Hudson studies may suggest use of some combination of total and out-of-pocket costs. Total out-of-pocket costs to the commuter as defined in this paper include maintenance costs, tire costs and gasoline costs. The auto owner's insurance, registration, license and depreciation are not considered. The out-of-pocket cost per car-mile was computed by dividing total annual miles into total out-of-pocket costs.

Cost Per Passenger-Mile and Cost Per Trip for Commuters

The commuter cost per passenger-mile was obtained by dividing the cost per commuter car-mile by the number of commuters per car. The cost per commuter trip was computed by multiplying the cost per passenger-mile by the length of the one-way commuter trip.

RESULTS

That results of the study indicate that:

1. The average commuting trip for trans-Hudson auto commuters varies from 61 miles in Suffolk County to 12 miles in Hudson County. The weighted average length is 22. 9 miles. The average length for the United States is only 7. 1 miles. The longer trans-Hudson trip produces more miles of travel per year. This, in turn, provides a larger base for writing off fixed costs.

According to this study, a trans-Hudson commuter living in Suffolk County would travel a total of 34, 300 miles annually. This is 10. 1 times the national average! However, the 1960 Census data indicate very few trans-Hudson commuters from Suffolk County. At the other end of the scale is the Hudson County trans-Hudson commuter. He drives his auto a total of only 8, 800 miles per year. The weighted average of 14, 990 total annual miles per year for all counties is 11, 590 miles above the national average.

2. The average life of an auto, as developed in this study, is 9 years. The median for all auto owners in the New York-New Jersey Metropolitan Area is estimated to be 8. 5 years. However, this study indicates that the average car life for trans-Hudson commuters drops to 6. 8 years because of the relatively high annual mileage accumulated by the trans-Hudson commuter. Therefore, trans-Hudson commuters probably are more frequent auto purchasers than other auto owners.

3. Operating costs outweigh fixed costs for trans-Hudson commuters. This differentiates trans-Hudson commuters from low mileage drivers whose fixed cost outweighs operating costs. It would be expected, therefore, that the trans-Hudson commuter is more sensitive to changes in operating costs. The sensitivity of operating costs and, hence, total costs to mileage changes is apparent in Table 1. The total annual costs for trans-Hudson commuters from peripheral counties is significantly higher than the total costs for close-in counties. The range estimated in Table 1 is from $2, 147 in Suffolk County to $987 in Hudson County.

4. The weighted average cost of 8. 3 cents per vehicle-mile for all auto travel by trans-Hudson commuters is low. It ranges from 11. 2 cents in Hudson County to 6. 2 cents in Mercer County. The average is 3. 5 cents below a typical driving cost of 11. 8 cents per vehicle-mile (4). Again, the cause is a larger annual mileage base. Important differences in cost occur between New York City and Hudson County, and the surrounding areas. The average is 10. 1 cents per vehicle-mile for the five central counties and 7. 3 cents for the others.

5. Total commuter costs per trip are higher for trans-Hudson auto commuters as compared to the typical commuter trip in another city because the average trans-Hudson commuter trip is longer—22. 6 miles instead of 7. 1 miles. The average out-of-pocket cost for trans-Hudson commuters is 2. 8 cents per mile times 22. 6 miles or $0. 63 exclusive of tolls and parking. The national average, at an assumed out-of-pocket cost of 3 cents per passenger-mile, is $0. 21.

Future Studies

Several assumptions in this report lend themselves to future study on a county-by-county basis. These include the amount of non-commuting miles, the average cost per car, and the average occupancy of non-commuting trips. Future surveys should endeavor to verify assumptions in this area and establish their effect on the final cost estimates. Also suggested is a larger sample of automobile maintenance cost data.

One source of maintenance cost information might be maintenance surveys such as those conducted by "Consumer Reports."

Another important area for future study is the variability in costs for individual drivers as compared to average costs for all drivers. One example is the difference in costs as seen by a one-car family and a two-car family. Presume that the two-car family considers total costs for one or both cars, whereas a one-car family does not. This would provide one explanation for an average driver cost that falls somewhere between out-of-pocket and fully distributed costs. A second example is the concept that the typical driver owns a car for general purposes and, therefore, has the car available for commuting. The approach is used to justify assignment of only out-of-pocket costs to auto commuting. It would seem difficult to use this approach in the case of the trans-Hudson commuter from Suffolk County, for example, whose commuting mileage represents 85 percent of total mileage.

A final area suggested for future study is the auto passenger. Division of auto costs by the number of passengers per vehicle assumes that all vehicle occupants have an identical view of costs. This may hold true in a commuter's auto pool but it is likely to be a false assumption for family travel.

CONCLUSIONS

It is concluded that the empirical process of estimating auto costs for each county, as outlined in the text, produces reasonable cost levels. The estimating process responds to the substitution of significant cost changes such as variable commuter trip distance, thus making it available for use in other auto cost estimating problems.

The total annual costs per car and the operating cost per car-mile vary significantly. Therefore, it is concluded that the cost breakdown by county is justified. For instance, total out-of-pocket costs vary from $1,194 for a Suffolk County commuter to $427 for a Hudson County commuter. Costs per car-mile, as given in Table 3, vary from 11.2 cents to 6.2 cents on a fully allocated basis and from 4.9 cents to 3.4 cents on an out-of-pocket basis for Hudson vs Mercer County.

It is important to relate costs developed in this study to those developed by others. For instance, the out-of-pocket costs are significantly higher than the 2.78 cents used in the Chicago Area Transportation Study for 20-mph speeds. This difference appears to be due to the exclusion of maintenance charges from the Chicago estimate on the simplifying assumption that no significant changes in maintenance cost occur due to varying auto speeds within the limits of normal highway commutation. This does not

TABLE 3

SUMMARY OF COSTS (Cents)

County	Per Car-Mile		Per Passenger-Mile	
	Total Cost Basis	Out-of-Pocket Cost	Total Cost Basis	Out-of-Pocket Cost
Group 1				
New York	10.4	4.8	5.5	3.0
Queens	8.7	4.6	4.8	2.9
Kings	9.7	4.7	5.1	2.9
Bronx	10.6	4.9	5.6	3.1
Hudson	11.2	4.9	5.9	3.1
Weighted average, Group 1	10.1	4.8	5.4	3.0
Group 2				
Richmond	7.8	4.2	4.3	2.8
Nassau	6.9	3.9	4.1	2.6
Suffolk	6.3	3.5	4.2	2.7
Westchester	7.1	4.0	4.2	2.7
Rockland	7.1	3.8	4.4	2.9
Orange	6.4	3.6	4.3	2.8
Essex	7.4	3.9	4.4	2.6
Union	7.6	3.9	4.2	2.6
Bergen	7.6	3.9	4.2	2.6
Passaic	6.9	3.8	4.1	2.5
Morris	6.4	3.5	4.3	2.7
Middlesex	7.0	3.8	4.7	2.9
Monmouth	6.3	3.4	4.2	2.6
Somerset	6.4	3.4	4.3	2.7
Mercer	6.2	3.4	4.1	2.6
Weighted average, Group 2	7.3	3.9	4.3	2.7
Overall weighted average	8.3	4.2	4.6	2.8

necessarily mean that the Chicago study uses a lower overall auto cost than is indicated by the data in this report. The Chicago study adds costs per vehicle-mile for accidents and time that increases the total per vehicle-mile to 10.43 cents at average speeds of 20 miles per hour (5). It is concluded that the results of this study are compatible with previous area transportation studies.

The primary purpose of this study is to determine a per passenger-mile cost for trans-Hudson auto commuters. The results of this study indicate that out-of-pocket passenger-mile costs do not vary by county as much as might be expected. Therefore, it is concluded that only two costs are required. The costs are derived from Table 3. They are an average of out-of-pocket costs for (a) the five close-in counties, and (b) an average of costs for all other counties. A cost of 3.0 cents per passenger-mile is recommended for commuter travel originating in both the four most populous boroughs of New York City and in Hudson County. A cost of 2.7 cents is suggested for commuter travel in all other counties.

These out-of-pocket costs can be checked by a comparison to national data. For instance, a total cost of 6.6 cents per passenger can be obtained by dividing 11.8 cents per mile by the national average of 1.8 persons per vehicle. If this cost is for a commuter trip of 7.1 miles, then the distribution of this cost would be most similar to the distribution shown in Table 1 for the 12.0-mile trans-Hudson trip by a Hudson County commuter. Operating costs are 43 percent of total costs per Hudson County commuter. Multiplication of 6.6 cents by 43 percent produces an out-of-pocket cost per passenger-mile of 2.8 cents. It is concluded that out-of-pocket costs per passenger-mile for those drivers who commute distances close to the national average are similar to out-of-pocket costs for drivers elsewhere.

However, it also is concluded that this study develops significantly lower overall costs per passenger-mile than auto cost studies developed for other purposes (6). For instance, many studies of auto costs are designed primarily for automobile salesmen, whose continuous driving requires a more luxurious vehicle, often with air-conditioning. Other studies select a relatively heavy, high-powered car as the basis for developing costs (7). Yet it is apparent that a large percentage of families probably use either an older car or a small, foreign car for commuting. Obviously, maintenance and gasoline are lower for older cars and smaller cars.

Other studies also depreciate cars over a 5-year period. "Automobile Facts and Figures" indicates that the average life of all cars in the New York-New Jersey area probably is closer to 9 years. Obviously, depreciation over an additional 4 years produces considerably lower depreciation charges per year. Finally, Table 1 illustrates that a trans-Hudson commuter travels more miles per year, which provides a larger base for the allocation of fixed costs. All of the above factors reduce total costs per car-mile.

The low costs per mile indicate that trans-Hudson auto commuting is relatively inexpensive. Such is not the case. For instance, a 20-mile commuter rail trip from Union County, New Jersey, to downtown Manhattan via the Erie-Lackawanna Railroad costs the user about 91 cents, exclusive of parking costs at the New Jersey station. A similar trip by auto using the above assumptions would cost less, about 52 cents if only out-of-pocket operating costs are considered. However, the costs of tolls (25 cents) and average parking costs per trip (70 cents) per auto, divided by 1.5 passengers per vehicle, results in an additional charge to the auto commuter of 64 cents. In other words, average auto commutation costs at least $1.16 per trip or 25 cents more than the average rail commutation fare. A computation including total vehicle costs of 7.6 cents per mile would make auto commuting 74 cents more expensive than rail travel! It is concluded that total auto commutation is more expensive than rail commutation particularly because of parking costs.

Obviously, the amount of existing trans-Hudson auto commutation requires an alternative explanation. Additional studies dealing with individual goals and values would be useful. However, the extensive use of the automobile in the face of the preceding economics suggests three preliminary conclusions. One conclusion is that there is a lack of convenient alternate modes of transportation for many trips. Perhaps the clearest example of a lack of alternate transportation is a trans-Hudson commutation trip between Westchester and Rockland Counties. The Tappan Zee Bridge is the only direct link between these counties and there is no commuter bus service across the bridge. Therefore, the commuter does not have any alternative but to drive. In this instance, as in many others outside of Manhattan, the trans-Hudson commuter probably does not have a parking charge at his destination. This reduces his costs to a level comparable to rail transportation fares into Manhattan.

A second conclusion is that the use of an average occupancy figure does not consider that people use car pools to reduce the costs per passenger. Automobile commuting for the Union County to lower Manhattan trip is equal to the rail trip in terms of cost per passenger when there are three passengers per vehicle. Car pools for auto commuting trips to areas without parking charges can produce lower per passenger-mile costs than rail commuting to Manhattan.

A final conclusion is that a small segment of auto users may find trans-Hudson commuting to be "profitable." This group would be the salesman type of commuter who requires a car for several trips during the day, or for carrying samples. He is considered a commuter if he crosses the Hudson River during the rush hour. The out-of-pocket cost per passenger-mile for a single vehicle occupant from Union County is 8.7 cents per mile if he parks in lower Manhattan. Other salesmen make many separate stops or serve communities outside Manhattan. These trips drop to 5.2 cents or less per vehicle-mile without parking charges. Employers of salesmen in this area and elsewhere use mileage allowances as a form of compensation. The travel is profitable because the salesman may receive an allowance of 10 cents per mile from his employer as a business expense. Thus, he can defray all or most of his commuting cost if he uses a moderately priced automobile.

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Appendix A

COUNTY ORIGIN AND DESTINATION PATTERN OF TRANS-HUDSON AUTO COMMUTERS IN NEW YORK-NEW JERSEY AREA

From	To: N.Y.	Rich-mond	Kings	Queens	Nassau	Suf-folk	Bronx	West-chester	Rock-land	Orange	Bergen	Passaic	Morris	Essex	Hudson	Union	Mercer	Somer-set	Middle-sex	Mon-mouth	Fair-field	New Haven	Totals	Percent
New York	—	73	—	—	—	—	—	—	299	45	2390	657	117	853	1470	327	27	42	140	45	—	—	6485	8.70
Richmond	1063	—	570	192	42	23	38	16	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1944	2.61
Kings	—	446	—	—	—	—	—	—	66	72	1512	467	98	1079	2312	468	37	—	190	33	—	—	6780	9.09
Queens	—	144	—	—	—	—	—	—	119	24	1304	311	63	634	1111	201	26	—	109	44	—	—	4090	5.49
Nassau	—	52	—	—	—	—	—	—	45	—	348	56	—	186	168	67	—	—	46	33	—	—	1001	1.34
Suffolk	—	8	—	—	—	—	—	—	8	—	69	—	—	33	53	—	—	—	—	—	—	—	171	0.23
Bronx	—	36	—	—	—	—	—	—	287	85	2533	624	94	222	1112	162	—	—	124	44	—	—	5324	7.14
Westchester	—	21	—	—	—	—	—	—	371	223	692	88	—	238	197	115	—	—	—	—	—	—	1945	2.61
Rockland	3942	—	207	193	52	11	717	1388	—	—	—	—	—	—	—	—	—	—	—	—	—	—	6510	8.73
Orange	327	—	89	41	—	—	62	292	—	—	—	—	—	—	—	—	—	—	—	—	—	45	856	1.15
Bergen	17469	—	1263	951	210	85	1850	1124	—	—	—	—	—	—	—	—	—	—	—	—	95	—	23047	30.92
Passaic	1530	—	153	134	33	11	114	93	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2068	2.77
Morris	1171	—	118	88	—	—	44	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1421	1.91
Essex	2657	—	328	274	45	—	83	85	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3472	4.66
Hudson	3043	—	560	548	61	—	126	129	—	—	—	—	—	—	—	—	—	—	—	—	—	—	4467	5.99
Union	1298	—	289	159	—	—	30	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1776	2.38
Mercer	60	—	7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	67	0.09
Somerset	237	—	55	28	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	320	0.43
Middlesex	1167	—	196	101	160	33	66	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1723	2.31
Monmouth	855	—	106	60	21	—	—	39	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1081	1.45
Fairfield	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0	0
New Haven	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0	0
Totals	34,819	780	3941	2769	624	163	3130	3166	1195	449	8848	2203	372	3245	6423	1340	90	42	609	199	95	45	74,547	100.00

Source: 1960 Census Journey-to-Work.

Appendix B

COMPUTATION OF COMMUTER TRIP LENGTH

"Automobile Facts and Figures" shows average auto occupancies for work trips (1. 3), other trips (2. 1) and all trips (1. 8). Thus, we calculate the average annual mileage for work trips and all other trips approximately as follows. Let a = mileage of work trips, b = mileage of all other trips, and c = total mileage per year.

Then

$$a + b = c \tag{1}$$

Also, the relationship of individual auto occupancies permits:

$$1.3a + 2.1b = 1.8c \tag{2}$$

Finally, we know that:

$$c = 9,500 \text{ miles} \tag{3}$$

Combining Eqs. 2 and 3 we obtain:

$$1.3a + 2.1b = 17,100 \tag{4}$$

Dividing Eq. 4 by 1. 3 results in:

$$a + 1.6b = 13,150 \tag{5}$$

Next, we subtract Eq. 1 from Eq. 5:

$$\begin{aligned} a + 1.6b &= 13,150 \\ a + b &= 9,500 \\ \hline 0.6b &= 3,650 \\ b &= 6,100 \text{ miles} \end{aligned} \tag{6}$$

Finally, we substitute Eq. 6 in Eq. 1:

$$\begin{aligned} a + 6,100 &= 9,500 \\ a &= 3,400 \text{ miles} \end{aligned} \tag{7}$$

Thus, we see that the average car travels approximately 3, 400 miles a year for commuter purposes. Next, we compute that the car is driven to work 240 days a year. This is done by subtracting 104 weekend days, 11 holidays and sick days and 10 vacation days from 365 days. The division of commuter miles by 480 commuter trips results in a computed one-way commuter trip length of 7. 1 miles. This compares favorably to a value of 7. 2 miles shown by a nationwide automobile use study done by the Bureau of the Census for the Bureau of Public Roads in 1965.

Relationships Between Drivers' Attitudes Toward Alternate Routes and Driver and Route Characteristics

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A home-interview study was carried out in order to investigate the relationships between the reasons drivers cite for choosing a particular route rather than an alternate for a trip and the characteristics of the drivers and the alternative routes. In examining constrained responses in which people gave reasons for choosing a particular route for a trip, tests were made to determine whether the importance of the various reasons differed with the purpose of the trip. Principal components factor analysis was used to determine whether responses about different reasons for route choice were measuring the same or different underlying values. Respondent's attitudes were examined to determine whether they were influenced by the socioeconomic characteristics of the people or by the performance characteristics of the routes. Statistical explanation of the attitudes, in terms of driver and route characteristics, was approached by three methods: canonical correlation, multiple regression, and grouping techniques. The results of these analyses are presented, and conclusions are drawn regarding the dependence of attitudes toward route choice upon persons and route characteristics.

•THE traditional benefit-cost analysis of highway improvement projects includes four primary types of user benefits to be derived from highway improvements: (a) reduction in cost of vehicle operation, (b) reduction in accidents, (c) reduction in strain and discomfort, and (d) savings of time. The valuation of each of these elements is a difficult problem which has not been adequately solved.

Some maintain that the value of time should be equal to the wage rate, because it can be assumed that time saved in travel can be put to income-producing labor. AASHO recommends assigning a value of $1.55 per hour to the time saved due to a highway improvement, although there is no strong theoretical basis for the selection of this particular value. Similarly, safety is valued by multiplying the estimated reduction in fatal accidents per annum by "a round sum which represents the loss due to one death, 35 personal injuries, and 210 property damage accidents—the average ratio of these types." The round sum currently recommended is $89,000 per fatality (2).

There are doubts that the valuations of benefits described for highway improvements bear any close relationships to the perceptions of cost and value which may be held by the highway user (9). If this type evaluation is accepted, there are still some questions which remain unanswered. Should a single value for the rich and the poor be used, or for the person making a trip to shop and another making a trip to work? Should the value of 5 minutes saved in a 15-minute trip be the same as the value of 5 minutes

Paper sponsored by Committee on Urban Transportation of Persons (Costs) and presented at the 46th Annual Meeting.

saved in a 3-hr trip? Because time savings often amount to half of the benefits accruing from a highway improvement project, the arbitrary nature of the values used for time is particularly disturbing.

The aim of this study is to determine whether subjective statements made by drivers about their perception of values in a choice between alternative routes for a trip are systematic and consistent functions of the characteristics of the respondents and of the routes about which they respond. If systematic and consistent relationships are found to exist, it is hoped that this study will lead to a better understanding of personal perceptions of benefit, and of how these perceptions differ among people. Such understanding could lead to further consideration of these perceptions in the evaluation of existing and proposed criteria for selection among alternative projects.

HOME-INTERVIEW PROCEDURE

To obtain the information required to carry out the investigation, a home-interview form was constructed, tested, and revised. Constrained-response type questions were used for the collection of most of the information and to facilitate the quantitative analysis of the data. Constrained-response questions often reflect the views and attitudes of the person constructing the interview form, and thus tend to introduce bias into the results obtained. Therefore, about 20 pilot interviews were conducted to minimize bias. These consisted of open-ended questions; the constrained-response questions were constructed only after a careful study was made of the answers to the open-ended questions. Every effort was made to word the questions in a neutral manner, and to incorporate the points raised by the respondents in the open-ended pilot interviews. In addition, some redundancy was introduced into the final questionnaire form by including both open-ended and constrained-response questions on several issues. The comparison of the responses to the two types of questions revealed how the respondents interpreted some of the key words used in the constrained-response questions.

During the interview, information was obtained about the factors which the respondent considered important in the choice of routes for a trip to work, a trip to shop for clothing, and a trip to visit a friend. In addition, detailed information about the socioeconomic and demographic characteristics of the respondent was obtained. The respondent was also asked to draw, on a map supplied by the interviewer, the routes which he perceived as possible alternates for his trip to work. This enabled the gathering of detailed information about the characteristics of these routes which was necessary for the analysis. No data were gathered about the routes actually used in the trip to visit a friend or to shop for clothing, because this would have made the interview too lengthly for the respondents, and because the author's time constraints would have made thorough analysis of the information impossible.

A sample of several hundred potential subjects was drawn from the R. L. Polk and Company's 1963 directory for Evanston, Illinois. Prospective subjects were first mailed a letter which explained the purposes of the research and the nature of the interview. About one week after mailing the letter, subjects were telephoned in order to make an appointment for the interview. About 20 percent of the people in the sample had moved, died, or had become otherwise unreachable since 1963. Thirty-five percent of the people to whom letters were sent refused to cooperate, the remaining 45 percent agreed to participate and were consequently interviewed. The refusal rate in the nonwhite neighborhoods was approximately 10 times the refusal rate in the white areas. In addition, the women contacted refused to participate about twice as often as the men. As a result, the sample is biased toward white males as compared with a truly random sample of the population of Evanston.

Of the respondents interviewed, 21 percent were women and 79 percent were men. The mean age of the respondents was 49 years, although they ranged in age from 19 to 78 years. Household sizes varied from one to 8 persons, with a mean value of 3 persons per household. The average level of education among the subjects was 14.7 years, with the lowest level being 6 years, and the highest being 20 years. Twelve percent of the interviewees were engaged in blue-collar occupations, 72 percent were in white-collar but nonprofessional positions, and 16 percent were professionals. The sample had a mean family income of approximately $14,800 per year, and 65 percent of the respondents owned their own homes, whereas 35 percent rented houses or apartments. About 85 percent of the respondents had moved to their present homes from others in the Chicago Metropolitan Area, while 15 percent had come from outside the metropolitan area. The average family had lived at its present address for a little more than 9 years. Only 35 percent of the sample, however, was born in the Chicago Metropolitan Area. Approximately 43 percent of the respondents worked in the CBD of Chicago, and they had an average trip to work which took 28 minutes and covered 9.7 miles. The trips varied, however, from a few blocks in length to a 65-minute journey to work.

This brief profile indicates that the responses measured are those of the citizens of a stable upper-middle-class commuter suburb with a lower proportion of home owners than most typical commuter suburbs. The members of the community are relatively well educated. The characteristics of the respondents should be borne in mind by the reader, because the measurements made and the relationships found can be assumed to be valid only over the ranges of the variables actually observed in the sample. Although it was a pilot study, it was useful nonetheless for testing methods of analysis and for formulating hypotheses regarding the interactions between the variables measured. It cannot be concluded that other groups of people would respond in a similar manner, although the methods of analysis proposed would certainly be applicable to other respondents.

Lower limits on the reliability of all constrained-response questions were computed according to the method devised by Guttman (8). The mean lower limit found was 0.47, and since this method yields an extremely conservative lower bound, the survey items have been taken to be reliable measurements of the attitudes and responses of the persons interviewed.

DIFFERENCES IN ATTITUDES WITH TYPE OF TRIP

Twenty-one constrained-response questions were given to each respondent to determine which characteristics of the alternative routes were important in his choice of a route for his trip to work. The same questions were repeated for a trip to "visit a friend," and another for "shop for clothing." Table 1 gives a listing of the statements. The respondent circled number 4 if the statement represented a very important factor in his choice of a route, 0 if the factor was very unimportant, and a number between the extremes if his feelings were better represented by such a response. The ordering of the statements was changed with each trip type to minimize the recollection of previous answers. Because the responses were ordinal in nature, a psychological-scaling method, based on the law of categorical judgment, was used to convert these responses to values which could be operated on as interval and ratio scales, and thus to facilitate some of the quantitative analysis which follows (6).

To determine whether the responses to each of the statements about route choice were distributed similarly or differently for each of the three trip types, the nonparametric Kolmogorov-Smirnov two-sample test was employed (15). Table 2 shows that for 14 of the 21 attitude variables considered, the null hypothesis that there was no difference between the distributions of attitudes among trip types could not be rejected at the 99 percent level of confidence. Safety, however, was significantly more skewed toward the important end of the scale for route choice in visit trips than in work trips; the same is true for pleasant scenery, pavement smoothness, and less hilliness. Although trip time, less congestion, and absence of stops and interruptions received the highest mean scores for all trip types, the results indicate that safety, scenery, and pavement smoothness are considered more important for visit trips than they are for work trips. This perhaps indicates the businesslike nature of the work trip as compared to the more leisurely nature of the visit trip. In the former, getting to the destination promptly is the most important criterion, but the latter enables the driver to consider other factors related to the pleasure of driving on a safe, smooth, scenic route.

The responses for the presence of more stores, service stations, and restaurants as a factor in route choice were more skewed toward the unimportant end of the scale

TABLE 1

LIST OF STATEMENTS ABOUT REASONS FOR ROUTE CHOICE

Statement	Scale: Very Important — Very Unimportant
I choose the route I use most frequently to drive to work because:	
It costs me less to drive on that route than it does on others.	4 3 2 1 0
There is greater safety on that route than there is on others.	4 3 2 1 0
There is less congestion on that route than there is on others.	4 3 2 1 0
The distance is shorter along that route than it is along others.	4 3 2 1 0
The road is less hilly along that route than it is along others.	4 3 2 1 0
There are fewer turns along that route than there are along others.	4 3 2 1 0
The trip takes less time along that route than it does along others.	4 3 2 1 0
There are fewer traffic signals along that route than along others.	4 3 2 1 0
The scenery is more pleasant along that route than it is along others.	4 3 2 1 0
There is greater visibility of what is ahead along that route than along others.	4 3 2 1 0
There are more lanes on that route than on others.	4 3 2 1 0
There is less strain and discomfort to driving on that route than on others.	4 3 2 1 0
There are fewer stops and interruptions to driving on that route than on others.	4 3 2 1 0
There are fewer trucks and buses on that route than there are on others.	4 3 2 1 0
The pavement is smoother on that route than it is on others.	4 3 2 1 0
There are fewer full-stop signs on that route than there are on others.	4 3 2 1 0
The route is less curvy than others.	4 3 2 1 0
The lanes are wider than on other routes.	4 3 2 1 0
There are more stores, service stations, and restaurants than along other routes.	4 3 2 1 0
There are fewer stores, service stations, and restaurants than along other routes.	4 3 2 1 0
There are fewer pedestrians crossing along that route than along others.	4 3 2 1 0

for the work and visit trips than for the shopping trip; whereas the presence of fewer stores, service stations, and restaurants was more important in the trip to work than in other trip types. These responses, together with comments from the respondents during the course of the interviews, seem to indicate that many people do not mind the congestion and delay associated with commercial development, if the purpose of their trip is to use the services of the establishments. Many said that they liked to pass stores on a shopping trip because it made them aware of possible alternate destinations. On the other hand, commercial development, and the traffic characteristics

TABLE 2

RESULTS OF KOLMOGOROV-SMIRNOV TEST OF SIGNIFICANCE OF DIFFERENCES BETWEEN TRIP TYPES IN ATTITUDES TOWARD ROUTE CHOICE[a]

Attitude Variable	Trip-Type Pairs		
	Work-Visit	Work-Shop	Visit-Shop
Costs less	No	No	No
Greater safety	Yes	No	No
Less congestion	No	No	No
Distance shorter	Yes	No	No
Less hilly	Yes	Yes	No
Fewer turns	No	No	No
Less time	No	No	No
Fewer traffic signals	No	No	No
Scenery more pleasant	Yes	No	Yes
Greater visibility	No	No	No
More lanes	No	No	No
Less strain and discomfort	No	No	No
Fewer stops and interruptions	No	No	No
Fewer trucks and buses	No	No	No
Pavement smoother	Yes	No	No
Fewer full stops	No	No	No
Less curvy	No	No	No
Lanes wider	No	No	No
More stores, service stations, etc.	No	Yes	Yes
Fewer stores, service stations, etc.	No	Yes	No
Fewer pedestrians	No	No	No

[a]Yes indicates significant difference. No indicates no significant difference (level of significance = 99%).

it brings, seems to detract from the directness sought in the work trip and the relaxation sought in the visitation trip.

The importance of choosing a route with shorter distance than other routes was distinctly bimodal for work trips with very important responses only slightly more numerous than very unimportant responses. For visit trips, however, distance did not display such a bimodal distribution. An open-ended question asking the respondent what factors he thought affected travel time on a route showed that many associated trip time with trip distance, and others associated trip time with congestion rather than distance. This may help to explain the bipolar response to the distance variable for the work trip, in which undelayed access to the destination is apparently more important than it is for other trip types.

Factor Analysis of Work-Trip Attitudes

The list of route characteristics which were considered and rated by the respondents contains some statements that are redundant and overlapping with others on the list. For example, the statement that "there is less congestion on that route than there is on others" and the statement that "there are fewer stops and interruptions to driving on that route than on others" may mean the same thing to those drivers who perceive congestion as interference with uninterrupted driving along a street or highway. It would have been impossible to eliminate this redundancy on an a priori basis before the questionnaire was administered, because driver perceptions of the interrelationships were not known at that time. Because many of the 21 attitudinal measurements may actually be measures of the same or similar underlying values as others, an attempt was made to reduce this redundancy in the matrix of measurements. In order to accomplish this, a rotated principle components factor analysis (5, 10) was performed on the matrix of scaled responses to the statements about route choice. This technique serves to isolate independent dimensions of attitudes toward route choice; the set of factor loadings obtained is extremely instructive in that it enables one to examine the interrelationships among the responses to the 21 variables. Reduction of the

TABLE 3

WORK-TRIP ROUTE CHOICE ATTITUDE FACTORS AND FACTOR LOADINGS

Factor Number	Percent of Variance	Loading	Factor Name and Variable Names
1	26.5		Preference for Access Controlled Routes
		+0.765	More lanes on this route than on others
		+0.733	Fewer full-stop signs on this route than others
		+0.721	Lanes wider on this route than on others
		+0.606	Fewer traffic signals on this route than others
		+0.563	Fewer stops and interruptions to driving on this route than others
		+0.521	Fewer pedestrians crossing along this route than along others
		+0.513	Pavement smoother along this route than others
2	9.4		Preference for Less Congestion and Strain
		-0.821	Less congestion on this route than on others
		-0.607	Less strain and discomfort to driving on this route than others
		-0.593	Fewer trucks and buses on this route than others
		-0.514	Fewer stops and interruptions to driving along this route than along others
3	8.5		Preference for Safety
		+0.695	Greater safety on this route than others
		+0.638	Fewer turns along this route than along others
		+0.632	Route is less curvy than others
		+0.612	Route is less hilly than others
		+0.570	Greater visibility of what lies ahead on this route than on others
4	7.4		Preference for Shortest Route
		+0.780	Distance is shorter along this route than along others
		+0.677	Trip takes less time along this route than along others
		+0.603	Trip costs less along this route than along others
5	5.6		Preference for Commercial Development Along Route
		+0.903	More stores, service stations, and restaurants along this route than along others
6	5.1		Preference for Pleasant Scenery
		+0.772	Scenery is more pleasant along this route than along others
7	4.5		Preference for Absence of Commercial Development Along Route
		+0.753	Fewer stores, service stations, and restaurants along this route than along others
		+0.454	Fewer pedestrians crossing along this route than along others
		+0.449	Fewer trucks and buses along this route than along others

matrix to fewer orthogonal dimensions also makes the attempts at statistical explanation of attitudes reported later more manageable and more interpretable. Factor analyses were performed separately on responses about work trips, shopping trips, and visit trips. Since the results for the three trip types were essentially similar, and since quantitative data for the characteristics of the work trips only were gathered, the results of the factor analysis for this trip type only are reported here.

The factor analysis resulted in reduction of the 21 attitudinal variables for work trips to 7 orthogonal factors, which account for 67 percent of the variance in the original variables. Because the matrix of factor loadings reveals the interrelationships between the attitudinal variables, it is most instructive. Table 3 gives the 7 factors along with the variables which load heavily upon them and their factor loadings. The names assigned to these independent factors represent an interpretation of the meaning of the common nature of all the variables loaded heavily on each factor. The factors are, in order of variance which they "explain": preference for access controlled routes, preference for less congestion and strain, preference for safety, preference for the shortest route, preference for commercial development along a route, preference for pleasant scenery, and preference for absence of commercial development along a route. The 7 factors can be taken as being representative of the entire matrix of attitudinal responses, since they explain such a high proportion of the total variance.

The validity of the factors may be judged, to a great extent, by the subjects' responses to the open-ended questions. Factor 2, for example, shows that congestion, strain and discomfort, the presence of trucks and buses, and stops and interruptions along a route are perceived as being positively related to one another. The unconstrained-response question, asking what caused strain and discomfort when driving, elicited frequent answers of "heavy congestion," "stop and go driving," "bumper-to-bumper traffic," and "trucks and buses." The parallel between the responses to this question and the composition of factor 2 is impressive. Similar open-ended statements relate to other factors and lend confidence to the use of the 7 factors as true measures of driver attitudes.

At first glance, factor 5 and factor 7 appear to be inversely related, and hence their logical independence is subject to question. Although it would be inconsistent for a subject to rate both of these as important considerations in the choice of a route, there is no inconsistency in listing both as unimportant factors. Some respondents considered one important, others listed the other as being important, and some considered neither factor important, thus allowing the analysis to give the result of independence.

Relationships Between Attitudes Toward Route Choice and the Characteristics of the Respondents and Their Routes

It is hypothesized that a person's attitudes toward what is important in the choice of a route are dependent on the characteristics of the person and the nature of the trip, and the characteristics of the alternative routes available. This hypothesis is tested in this section, and attempts are made to quantify the functional relationships between the measured attitudes and the personal as well as trip characteristics of the respondents. These relationships are examined in three ways. First, canonical correlation coefficients are computed to test for significant relationships between the attitudes and the socioeconomic and demographic characteristics of the respondents, and between the attitudes and the trip characteristics. Second, multiple regression is used to express each of the 7 attitude factors as a function of the socioeconomic, demographic, and trip characteristics. Finally, a grouping analysis is performed to determine whether groups of respondents with distinct attitude patterns also display distinct patterns of socioeconomic or trip characteristic data.

The 18 socioeconomic and demographic variables which were measured for each respondent are given in Table 4. Note that some are continuous, some dichotomous (yes, no), and some ordinal. This fact had an important effect on the analysis which will be described later.

TABLE 4

SUMMARY OF SOCIOECONOMIC AND DEMOGRAPHIC VARIABLES MEASURED FOR EACH RESPONDENT

Respondent's sex (male, female)
Respondent's age, years
Respondent's race (white, nonwhite)
Size of respondent's household, people
Respondent's occupation (blue collar, white collar nonprofessional, professional)
Education of respondent, years
Number of drivers in respondent's household
Time respondent lived at present address, years
Time respondent lived at previous address, years
Previous address location (in Chicago metropolitan area, outside Chicago metropolitan area)
Place of birth of respondent (in Chicago metropolitan area, outside Chicago metropolitan area)
Home ownership status (own, rent)
Respondent's time on present job, years
Respondent's family income, thousands/year (11 categories)
Respondent's family car ownership
Type of residence (one family detached, one family row, two family, apartment)
Number of miles driven by respondent in previous year, thousands
Stage in family life cycle (6 categories based on age, marital status, and number of children)

In order to gather information about the characteristics of the work trip and the alternative routes perceived by the trip-maker, two supplementary approaches were used. First, questions were included in the interview about the nature of the trip and the alternative routes. In addition, the respondent indicated by marking on a detailed street map of Chicago, exactly what his alternative routes were. This enabled the gathering of quantitative information about the routes which could not be obtained directly from the home interview. Before presenting this data, however, a digression is necessary to describe the appropriateness and limitations of the data used.

Most of the respondents spoke of two alternative routes for their trip to work, although some cited as many as six or seven. In order to keep all the responses comparable to one another, the data actually used in this phase of the analysis were confined to two route alternatives—the preferred and second-best routes—for all respondents. The travel time used for each route was the respondent's estimated travel time. In order to measure actual travel time, the researcher would have had to traverse each route several times at the same time of day that each respondent made his work trip. This was not possible. The respondent's trip-time estimate is taken as a true measure of trip time, since respondent's estimates of trip distance and trip distances scaled off the maps were correlated by more than 0.9, and a driver is assumed to be more apt to look at his wristwatch than his odometer.

Traffic volumes on the routes were obtained from the Chicago Bureau of Street Traffic. Average daily volumes were multiplied by an hourly proportion to estimate volumes during the hour in which the respondent made the trip. Average volumes for a route are the result of weighting the volume on each portion of each route by the length of that portion. A serious limitation here is that the volume of traffic on a street or highway is not a true measure of its performance or traffic characteristics. A given volume on an arterial street might indicate congestion, whereas the same volume on a freeway might indicate free-flow conditions. The ratios of volume to capacity would have been more meaningful than volumes alone, but unfortunately design capacities were not available and therefore could not be used.

Two homemade sets of measurements on the routes were employed because better ones were not available. The number of intersecting arterials along each route was counted and included as a surrogate for delay and interrupted driving. The number of segments in a route was defined as the number of continuous portions of a route, each along a particular street or highway. This is, perhaps, a measure of the directness of a route. Clearly, the characteristics of the routes which are used in the analysis are inadequate to completely specify the nature and performance level of the alternatives. Nevertheless, in the absence of more useful data, these allowed us to make the preliminary and exploratory investigations presented here.

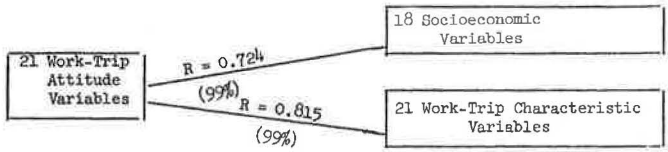
Table 5 gives a listing of the trip and route characteristics used in the study of the relationships just described. Rather than presenting a characteristic, such as traffic volume, for both the preferred and alternate routes, the actual value of the characteristic is shown for the preferred route, along with the ratio of the value of the characteristic on the preferred route to the value on the alternate route. This is done because attitudes may be related to both the absolute magnitude of the measured characteristic, and to the relative magnitudes among the alternatives. For example, if trip time is a variable which influences one's choice between routes, this choice might be influenced by both the absolute trip length (is it a 15-minute trip or a one-hr trip?) and the relative trip lengths among the alternative routes (is route A 5 minutes quicker than route B?). The use of the absolute value on the preferred route and the ratio of the value on the preferred to the value on the less preferred route seems to be the most reasonable method of capturing these two types of influences.

The hypothesis that the stated attitudes could be related to the characteristics of the respondents and their trip and route characteristics was first tested by computation of the canonical correlations between the sets of variates. Canonical correlation coefficients for sets of variables may be interpreted in much the same manner as is the product-moment correlation coefficient for a pair of variables (5, 11). Figure 1 shows the canonical correlation coefficients between the original sets of variables, and between the work-trip factors and the other two sets of variables (21 work-trip characteristics were used rather than the 24 given in Table 5 because of the obvious logical redundancy in some of them). The level of significance of these coefficients, computed according to Bartlett's method (1), is shown in parentheses for each coefficient. The coefficients for the work-trip attitude factors are lower than those for the raw variables because a portion of the variance in this set of variates has been eliminated, and because the number of degrees of freedom has been changed. The coefficients do indicate that there are strong relationships between the sets of variables, that these relationships are statistically significant, and that there is reason to further explore these relationships.

TABLE 5

SUMMARY OF WORK-TRIP AND ROUTE CHARACTERISTICS MEASURED FOR EACH RESPONDENT

Number of alternate routes cited
Percent of time using modes other than driving
Percent of time using preferred route
Percent of time using alternate route
Travels to work alone? (yes or no)
Uses car at work? (yes or no)
Trip made during peak hour? (yes or no)
Trip time, minutes, preferred route
Trip to CBD? (yes or no)
Distance on local streets, miles, preferred route
Distance on arterials, miles, preferred route
Distance on expressways, miles, preferred route
Total distance, miles, preferred route
Number of segments, preferred route
Number of intersecting arterials, preferred route
Average traffic volume, veh/hr, preferred route
Volume ratio (preferred route/alternate route)
Distance on local streets ratio (preferred route/alternate route)
Distance on arterial streets ratio (preferred route/alternate route)
Distance on expressways ratio (preferred route/alternate route)
Total distance ratio (preferred route/alternate route)
Travel time ratio (preferred route/alternate route)
Segments ratio (preferred route/alternate route)
Intersecting arterials ratio (preferred route/alternate route)



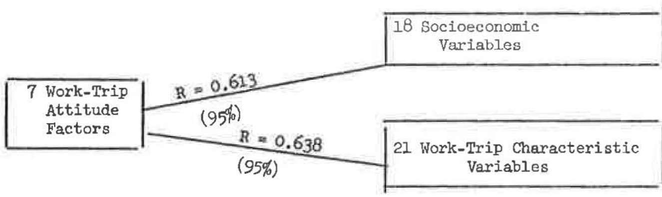


Figure 1. Canonical correlation coefficients between work-trip attitude variables and socioeconomic and trip characteristic variables, and between work-trip factors and socioeconomic and trip characteristic variables.

Multiple stepwise linear regression is the tool selected for use in the attempt to more closely scrutinize the relationships between the individual work-trip attitude factors and the driver's socioeconomic, demographic, and route characteristics. The multiple stepwise regression method, in its basic form, is restrictive in that it assumes a linear relationship between the dependent variable and each independent variable. Although transformations of the data and the use of nonlinear regression are ways to avoid this problem when necessary, they often become involved and too often reduce the interpretability of the results. The method employed here, called the dummy variable technique, allows the consideration of independent variables whose relationship to the dependent variable need be neither linear nor monotonic (17). The method permits the inclusion of independent variables which are continuous but which are not linearly related to the dependent variable, and also enables one to include qualitative or nominal variables, such as sex or occupation. The independent variable to be included in this manner is stratified into several discrete classes, each containing a particular value or range included in the original variable. Each class, except one, becomes a single dummy variable which takes on a value of unity if an observation falls in that class. The dummy variables representing the remaining categories each take on the value of zero. If the excluded category is the one into which the observation falls, all dummy variables representing that original variable become zero. Morgan has shown that a single standardized regression coefficient (beta coefficient) may be found for the set of dummy variables representing a single original variable (14). This beta coefficient, except for the fact that it has no meaningful sign, is interpretable as is the beta coefficient for a continuous linear variable, and may be compared to similar coefficients for linear variables and other dummy variables in the same regression equation.

Seven regression equations were computed, using each of the seven attitudinal factors as dependent variables. The independent variables used in each equation are the result of several trials in which all variables were at first represented as dummy variables, and then those which displayed a linear relationship with the dependent variables were replaced by the original continuous variable. Thus, each of the equations includes some linear and some dummy variables. Approximately 30 original independent variables were used in each equation. Although his number is large, they were all included in the final runs to allow inclusion of all the dummy variables associated with a given original variable. Since a stepwise regression program was used, in many cases a dummy variable entered in an early step, while other dummy variables associated with the same original variable entered much later—perhaps after the inclusion of several less significant linear variables.

In order to save space, only summary tables (Tables 6 to 12) showing the few independent variables which most strongly influenced each of the dependent variables are included in this report. The criterion for their selection is the magnitude of their beta, or standardized regression coefficients. Coefficients of determination (R^2) ranging from 0.36 to 0.58 were found for the seven regressions in their complete form.

Examination of Tables 6 through 10 indicates that the travel time for the trip to work appears among the few most important independent variables for five of the seven attitude factors. Thus, we may infer that the duration of the work trip has a strong influence on the factors considered important in the selection of a route for that trip from possible alternate routes. The respondents showed a general tendency, as trip time increased, toward (a) increasing preference for access control; (b) increasing preference for less congestion and strain; (c) increasing preference for safety; (d) decreasing preference for the shortest route; and (e) decreasing preference for the absence of commercial development along the route. The first three tendencies indicate an increasing importance attached to perceived performance levels of routes as trip length increases. The fourth indicates that one might be willing to sacrifice directness in order to choose a route of higher performance characteristics, and may also lead one to hypothesize that the perceived value of a time saving of given duration decreases as the total trip time increases. The fifth item is difficult to explain, and may even contradict the previous reasoning.

Table 6 shows that preference for access control is strongly associated with the number of intersecting arterials along the route—a measure of the lack of access control. People expressing strong preferences for access control were found to be using routes which tended to have fewer intersecting arterials. In addition to the number of intersecting arterials and the travel time, some socioeconomic and demographic variables have a rather strong relationship with preference for access control. Older people seem to display less of a tendency toward preference for access control than younger people—one might guess that this is related to the fact that older respondents grew up and learned to drive before freeways were available. This might indicate that as our population ages, and those born since the inception of freeways become the dominant proportion of the driving public, there will be more of a tendency toward use of access controlled facilities. Preference for access control was also found to decrease with increasing educational level, and to tend to increase with length of residence at the respondent's present address. One can see no logical explanation for the relationship between preference for access control and family size. Peak-hour travelers showed stronger preferences for access control than off-peak drivers, perhaps because of the congestion and delay associated with clogged arterial streets during rush hours.

TABLE 6

SUMMARY OF REGRESSION ANALYSIS OF WORK-TRIP ATTITUDE FACTOR NUMBER 1[a]

Independent Variable	Linear	Dummy	β
Number of intersecting arterials	x		0.496
Years of education		x	0.389
Travel time, minutes		x	0.373
Years at present address		x	0.367
Family size?		x	0.362
Age, years		x	0.352
Trip made in peak hour?		x	0.302

[a]Dependent variable: preference for access controlled route.

TABLE 7

SUMMARY OF REGRESSION ANALYSIS OF WORK-TRIP ATTITUDE FACTOR NUMBER 2[a]

Independent Variable	Linear	Dummy	β
Travel time, minutes		x	0.361
Distance on arterial streets, miles	x		0.352
Trip to CBD?		x	0.323
Years at present address		x	0.308
Number of segments in route	x		0.271

[a]Dependent variable: preference for less congestion and strain.

Table 7 shows, as mentioned before, that preference for less congestion and strain in the work trip tended to increase with increasing trip length for the sample of respondents. People who expressed higher preferences for less congestion and strain seemed to be satisfying these preferences to some degree because their route choices tended to have shorter distances on arterial streets, and fewer "segments" in their routes. People who traveled to the CBD, where driving is likely to be hectic, showed lower preference for the absence of congestion and strain than did people whose destinations were elsewhere. Since the CBD is more likely to be congested than other parts of the city, this too indicates that the respondents' preferences are perhaps being satisfied to some degree by the existing highway network. Tenure of residence (a variable which is strongly correlated with age) also influenced preference for less congestion and strain, although the relationship was not monotonic.

In addition to becoming a more important reason for route choice as travel time increases, safety (Table 8), becomes more important as the ratio of the number of intersecting arterials on the respondent's preferred route to the number on his alternate route decreases. Holding other variables constant, people born outside the metropolitan area were more concerned with safety than those who were born and raised in close proximity to the bustling transportation network. Blue-collar workers and professionals rated safety as being more important in their choice of a route than did white-collar workers; lower and higher income people showed the same tendency with respect to middle-income people. Respondents who had been on their present job for a shorter period of time listed safety as being more important than those on their jobs for a longer period of time. Perhaps we might hypothesize that the former were more wary of safety because of their lack of familiarity with the alternatives than the latter.

Table 9 indicates that preference for the shortest route is most strongly affected by the average traffic volume on the route. As one might expect, increasing traffic volumes lead to increasing preference for the shortest route. Once again, travel time has a significant influence on the perceived importance of the factor in the route-choice decision. It is also interesting to note that the frequency with which the respondents use transportation modes other than driving also influences their preference for the shortest route. In general, those who drive most often place greater importance on

TABLE 8

SUMMARY OF REGRESSION ANALYSIS OF WORK-TRIP ATTITUDE FACTOR NUMBER 3[a]

Independent Variable	Linear	Dummy	β
Intersecting arterials ratio	x		0.424
Born in Chicago metropolitan area?		x	0.423
Travel time, minutes		x	0.405
Occupation		x	0.382
Income, thousands		x	0.306
Years on job	x		0.254

[a]Dependent variable: preference for safety.

TABLE 9

SUMMARY OF REGRESSION ANALYSIS OF WORK-TRIP ATTITUDE FACTOR NUMBER 4[a]

Independent Variable	Linear	Dummy	β
Average traffic volume, 100 veh/hr	x		0.562
Travel time, minutes		x	0.405
Percent of time using other modes		x	0.395
Age		x	0.307
Number of drivers in household	x		0.300
Ratio of distances on expressways	x		0.257

[a]Dependent variable: preference for shortest route.

seeking the shortest route than those who drive less often. With other variables held constant, as the ratio of expressway distance on the preferred route to expressway distance on the less preferred route increases, the preference for the shortest route decreases. This perhaps indicates that as the performance level of the preferred route becomes relatively better, one is willing to sacrifice directness in order to achieve the higher level of service. The respondent's age, and the number of drivers in his household have strong but non-monotonic effects on preference for the shortest route.

Table 10 shows the independent variables which most strongly influence the respondents' stated preference for commercial development along the routes which they choose for their trips to work. Drivers who used other modes of transport either very frequently or very infrequently showed lower preference for commercial development along their routes than others. Those who drove more, as indicated by the mileage they had driven last year, tended to show less preference for commercial development along their routes. As income increased, preference for commercial development along the routes tended to decrease, perhaps because the upper socioeconomic groups are less tolerant of delay than others. Again, the author can see no clear-cut logical justification for the importance of family size as an influence on preference for commercial development along the respondents' routes.

Preference for pleasant scenery along a route is apparently associated most strongly with the respondent's family size, tenure of residence, frequency of taking other modes, and social status, as indicated by income and education (Table 11). Unfortunately, the meanings of these relationships are difficult to interpret because they are all non-monotonic and lacking in clear-cut trends. Perhaps the grouping analysis which follows the regression results will shed more light on the nature of these relationships.

Table 12 shows the independent variables which were found to influence most strongly the respondents' preferences for the absence of commercial development along the routes which they chose for their trips to work. Drivers with longer trips tended to display less preference for the absence of commercial development than did those with shorter trips. More educated respondents showed lower preference for this factor than did those with less education. As the distance traveled on expressways by the respondents increased, so did their preference for absence of commercial development,

TABLE 10

SUMMARY OF REGRESSION ANALYSIS OF WORK-TRIP ATTITUDE FACTOR NUMBER 5[a]

Independent Variable	Linear	Dummy	β
Percent of time using other modes		x	0.762
Years at present address		x	0.458
Family size		x	0.377
Miles driven last year		x	0.313
Income, thousands		x	0.284

[a]Dependent variable: preference for commercial development along route.

TABLE 11

SUMMARY OF REGRESSION ANALYSIS OF WORK-TRIP ATTITUDE FACTOR NUMBER 6[a]

Independent Variable	Linear	Dummy	β
Family size		x	0.493
Years at present address		x	0.405
Percent of time using other modes		x	0.361
Income, thousands		x	0.294
Educational level		x	0.284

[a]Dependent variable: preference for pleasant scenery.

TABLE 12

SUMMARY OF REGRESSION ANALYSIS OF WORK-TRIP ATTITUDE FACTOR NUMBER 7[a]

Independent Variable	Linear	Dummy	β
Travel time, minutes		x	0.493
Years of education		x	0.406
Family size		x	0.309
Distance on expressways, miles	x		0.300
Total distance ratio (pref./less preferred)	x		0.217

[a]Dependent variable: preference for absence of commercial development along route.

again perhaps indicating that the routes selected did tend to display the desired characteristics. As the ratio of total distance on the preferred route to distance on the less preferred route increased, preference for absence of commercial development was found to decrease.

Although many of the findings of the regression analysis are interesting and have logical explanations, many are difficult to interpret. The strong relationships which appeared to exist between the work-trip attitude factors and the sets of socioeconomic and work-trip characteristics based on the canonical correlations are apparently quite difficult to quantify in terms of individual factors and variables. Although many of the regression results allow interesting logical explanations, a few of the relationships, such as the ones between family size and several attitude factors, defy explanation on logical grounds. First, another method of examining the interrelationships between the attitudes and the socioeconomic and work-trip characteristics will be examined, because it may lead to some conclusions which will help to extend those based on the given analysis.

The final method employed in the examination of the interrelationships between work-trip attitude factors and socioeconomic and work-trip characteristic variables was a grouping technique. The respondents were grouped so that those within groups were homogeneous in their attitudinal responses, and so that the groups differed in their patterns of attitudinal responses. Then, comparisons were made between the groups in terms of their socioeconomic, demographic, and work data to see how the attitudinal groupings differed in these characteristics.

The grouping technique had two stages. First, a correlation matrix was computed, showing the correlation between each of the 139 respondents (treated as variables) and all other respondents, with the factor scores on each of the seven attitudinal factors treated as observations on each respondent. Second, a simple linkage analysis was performed on this correlation matrix to isolate groups of respondents who were strongly related to one another (12). The groupings obtained in the linkage analysis were then used as inputs into a discriminant iterations procedure (3), in which discriminate functions were found, and group membership probabilities for each respondent's membership in each group were calculated. If a respondent had a higher probability of belonging

TABLE 13

SUMMARY OF COMPOSITION OF GROUPS FORMED BY LINKAGE ANALYSIS AND DISCRIMINANT ITERATIONS

Group 1
High preference for less strain and congestion High preference for pleasant scenery Low preference for shortest route
Oldest group Longest average trip length Largest number of trip segments Highest ratio of dist. (pref.)/dist. (less pref.) Highest ratio of segments (pref.)/segments (less pref.) Longest average distance on arterials
Group 2
Low preference for less strain and congestion Greatest preference for safety Least preference for absence of commercial development along route
Shortest average trip length Smallest prop. of work trips to CBD Smallest average distance on expressways Smallest average traffic volume Lowest average income
Group 3
High preference for access control Low preference for safety Low preference for commercial development along route
Youngest group Highest proportion of males Most mobile group (apt. dwellers short time pres. address, high prop. previous address outside CMA) Low number of intersecting arterials High mileage driven last year High proportion of CBD trips Small average distance on local streets
Group 4
Low preference for safety High preference for shortest route High preference for pleasant scenery
Large proportion of professionals/high income Highest average level of education High proportion of home owners High proportion of CBD trips Frequent use of other modes Small number of trip segments
Group 5
High preference for shortest route High preference for commercial development along route Low preference for pleasant scenery
Highest proportion of females Low educational level Highest proportion of blue-collar workers Long expressway distance High proportion of off-peak travelers Low distance on arterials
Group 6
Low preference for access control
High income High average age High educational level Longest average distance on local streets Shortest average distance on expressways Low proportion of trips in peak hour High ratio of intersecting arterials (pref.)/(less pref.) High ratio of segments (pref.)/(less pref.) Small proportion of respondents using car for work

to a group other then the one to which he was assigned, he was shifted to the group of higher probability, and the process was repeated. After six iterations the respondents were all found to be in the groups to which they had the highest probability of belonging. The resulting six groups are given in Table 13, which lists the attitudes and characteristics that are distinctive to each group.

Careful study of Table 13 shows many consistencies with the results of the regression analysis, but a few inconsistencies as well. The influence of increasing trip length on preference for higher levels of service, which was found in the regression analysis, seems to be upheld, to a high degree, by the composition of the groups. Thus in group one, high preference for less strain and congestion and strong preference for pleasant scenery are associated with the group that has the longest average trip length; group 2, the group with the shortest average trip length, displays the least preference for less strain and congestion, and the least preference for the absence of commercial development from its routes in the trip to work. The group with the highest preference for safety, however, is the one with the shortest trip length, and this finding contradicts the positive association between trip time and safety found in the regression analysis.

The regression finding that the respondents' preference for access controlled routes is strongly related to their age is also corroborated by the grouping analysis. Group 3, with the youngest average age of the six groups, has the highest preference for access control; group 6, with a high-average age, exhibits the least preference for controlled access among the groups. An interesting finding, which is consistent with accident statistics and auto insurance rates, is that the youngest group showed the least preference for safety in its choice of routes for its trips to work. A surprising finding is that the groups with the highest mean level of education and the highest proportion of professionals also found safety relatively unimportant.

The reader will recall that the regression results indicated that drivers' route choices tended to be in equilibrium with their attitudes. Drivers who preferred access control tended to make trips with higher proportions of their distances on expressways than on arterials, and on routes with fewer intersecting arterials than others. Drivers who expressed a low preference for the shortest route in their trip to work were using routes which were longer, with respect to their alternates, than drivers who expressed a strong preference for the shortest route. This finding of apparent equilibrium is upheld to some extent by the grouping analysis. For example, group 6 demonstrated a low preference for access control and the shortest average distance on expressways, the longest average distance on local streets, and the highest ratio of intersecting arterials on the preferred route to intersecting arterials on the alternate route. Group 3, with high preference for access control, demonstrated a low usage of local streets in its trips to work. Group 2, with the least preference for the absence of commercial development along its routes, had the smallest average distance on expressways.

Preference for pleasant scenery along the route to work was found, in the regression analysis, to be related to income, educational level, frequency with which other modes were used, years at present address, and family size, but the relationships found by dummy variable regression were not monotonic and were difficult to interpret. The grouping analysis sheds a bit more light on the relationships. In group 4, high preference for pleasant scenery is associated with high income, high levels of education, and frequent use of other modes of travel. In group 1, we find preference for pleasant scenery associated with older respondents, and those who make longer trips to work. In group 5, we find that low preference for pleasant scenery is associated with low levels of education, and high proportions of blue-collar workers. For the sample surveyed, a preference for pleasant scenery is clearly related to social rank, and becomes more important with increasing trip length.

CONCLUSIONS AND EVALUATION

The analysis indicates that reasonably strong relationships do exist between the attitudes of the respondents toward the type of route which they seek when they make a trip, and the characteristics of the respondents, their trips, and the routes to which they have been exposed. The relationships found could not have arisen randomly.

Although it was possible to investigate these relationships in some detail, the results were not always entirely satisfying because some of the relationships found could not be clearly explained on logical grounds. After a very brief recapitulation of the major findings of this section of the study some possible explanations will be offered for the shortcomings of the attempt to specify more effectively the individual attitudes in terms of person and trip characteristics.

The major findings of the preceding analysis may be summarized as follows:

1. People's preferences for various route characteristics do vary, and the variations can be related to the characteristics of the people, their trips, and the routes to which they have been exposed.
2. Responses to attitudinal statements about reasons for route choice do not vary greatly with the type of trip. Differences which do exist seem to be related to the grea importance of direct and quick access to the destination in the trip to work, and the increasing importance of amenities, such as comfort and pleasant scenery, in more leisurely visiting trips.
3. Factor analysis is a useful method for the reduction of a battery of attitudes about route choice to fewer independent and interpretable dimensions.
4. Drivers' attitudes toward which factors are important in the choice of a route for the trip to work appear to be strongly influenced by the length of the trip they are making.
5. Drivers seem to be able to satisfy their preferences for many route characteristics. Drivers who express preferences for many route characteristics actually tend to travel on routes which possess them, whereas drivers who express little preference for such characteristics tend to drive on routes which do not possess them.

There are several possible reasons for the strong relationships found between the attitude variables and some of the independent variables used in the regression analysis. Logical explanations for some of these are impossible or extremely tentative. For example, the family size of the respondents, or the number of drivers in their households, often appeared to exert a stronger influence on their attitudes than age, income, educational level, etc. We might intuitively expect a person's social status or stage in the life cycle to bear stronger relationships to his attitudes than some of the variables which were more important "explainers" of attitudes in the regressions. The probable cause of this result is the fact that the population of respondents is biased toward the upper-income levels and higher educational levels. Certain variables, including family size and number of drivers in the household, vary over as wide a range as one might expect to find in a truly random sample of American citizens; however income, education, and race contain much less variance in this sample than in a typical sample of drivers.

Because regression analysis is essentially a treatment of the covariation among variables, if certain variables have variances which are restricted to an abnormally small range, they will not appear as important as one might intuitively expect, whereas variables which are not so restricted in variance may be overemphasized. This is particularly possible in a small sample where chance covariations between, say, famil size and attitudes are more likely to occur than in larger samples. As was explained earlier, the measures used in the analysis as characteristics of the respondents' route were not adequate to fully specify the nature of those routes.

If the attitudes of individual drivers toward the characteristics of transportation facilities are to be effectively utilized in the evaluations of such facilities in order to make choices between alternatives correspond more effectively to the values of the users, we must first identify the elements of service on which the users place positive value, and the absence of which they perceive as costs. Second, we must learn something of the relative importance of these values, and the variations in the relative importance with variations in the characteristics of the people and in those of the facility. A third step which we may or may not want to take is the translation of these relationships to economic or monetary terms. This research has attempted to demonstrate that the first two steps are feasible, but has not attempted to wrestle with the third—a most difficult problem.

In spite of the limited success in some of the stages of the research, the methods used here have demonstrated that it is feasible to isolate the elements of value and cost as perceived by the driver, to examine interrelationships between these elements, and to relate them to the characteristics of the drivers and the facilities in question. It is hoped that this methodology, and the conclusions of this research will have application and value in the urban transportation planning and evaluation process.

ACKNOWLEDGMENTS

The research reported in this paper was done with the support of the Transportation Center at Northwestern University, through NCHRP Project 8-4. The author is grateful for this support, and for the help and advice of Professor William L. Garrison, Director of the Center; Professor Edwin Thomas, Director of Research; and Mr. Joseph L. Schofer, Co-Principal Investigator for Project 8-4.

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