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.

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[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).

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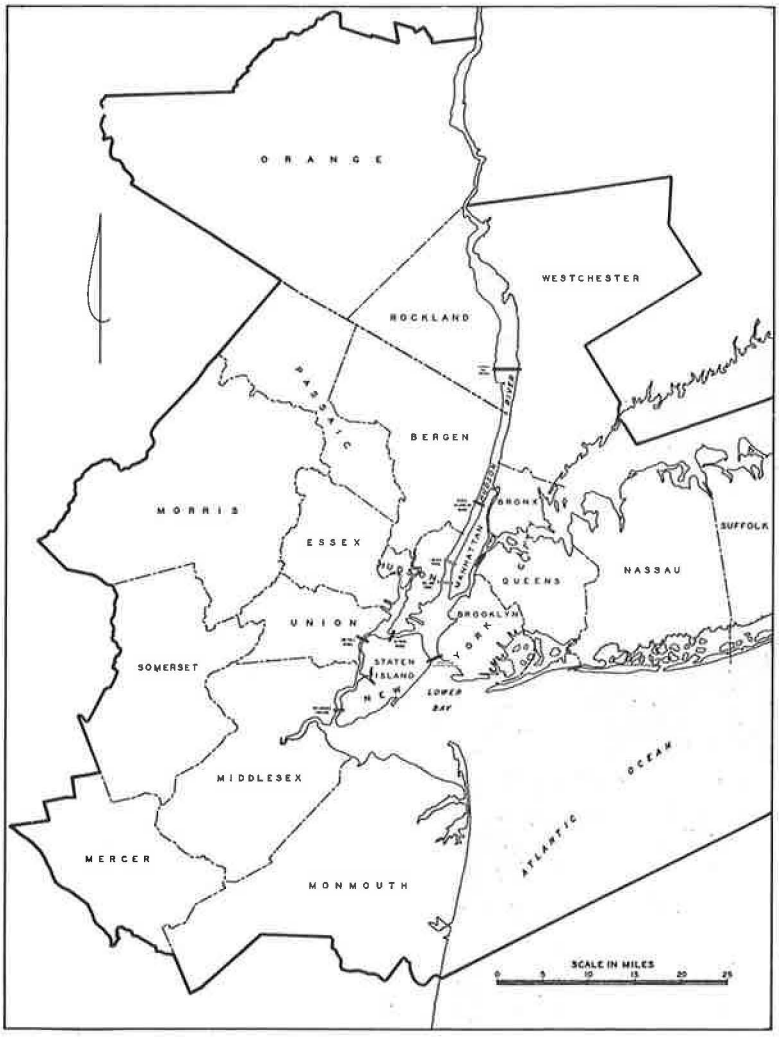

Figure 1. Twenty-county study area and location of tunnels and bridges.

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 and gallons 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.	Richmond	Kings	Queens	Nassau	Suffolk	Bronx	Westchester	Rockland	Orange	Bergen	Passaic	Morris	Essex	Hudson	Union	Mercer	Somerset	Middlesex	Monmouth	Fairfield	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.