Transit Ridership in an Intense Transit Environment: Some Observations

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Five transit services in an intense transit environment (the city of New York) were surveyed: four bus routes and one rail rapid transit route. In addition, surveys of express bus and automobile ridership on a section of the Long Island Expressway were considered to provide some further mode comparisons. The prime trip purposes were work and school: Work trips accounted for about two out of four trips; except for the premium services, school trips accounted for one out of four trips. Occupation and income generally reflected the source populations. The gender split varied from service to service; buses had the most females (60-80 percent) and automobiles the least (15 percent). Relative to the automobile, riders stated the prime reasons for transit as "automobile not available" or "parking problems." Express bus services drew heavily from public transit; the preferences for it were expressed primarily as comfort and convenience in terms that rank it as a mimic of the automobile—climate control, no transfers, and proximity to trip ends. A picture emerges of a hierarchy preference of modes: (a) automobile, (b) something that mimics automobile, and (c) conventional transit. A case study to replicate the modal gender differences required that two bias coefficients be introduced into a logit model that describes the situation: a distinct preference for bus as a transit mode and a disutility for the automobile that is equivalent to an incremental cost of $2/trip.

This paper presents the results of a set of surveys of transit riders conducted in a relatively well-served, intense transit environment (1). Rider surveys were generally conducted by using mail-back forms that were distributed on board five local transit services: four fixed-route bus routes and one rail rapid transit line. Results from other studies conducted at the Polytechnic Institute are integrated to provide a systematic view of the range of transportation alternatives available to the individual in the environment studied. These other studies include a survey of New York City express bus services and a study of Long Island Expressway (LIE) users.

The ridership studies were complemented by an extensive origin-destination study on the rail rapid transit service. These results are also reported here.

The intent of the study was to relate the ridership observed to both the source population and the ridership of other services and to deduce differences that might be specific to the mode or useful in the planning of transit services.

SERVICES SURVEYED

The five services surveyed are located in the city of New York, an environment that has a substantial transit infrastructure. There are, nonetheless, variations in the amount and type of service available within the city as well as variations in the density and character of the areas themselves.

The five services surveyed are shown in Figure 1 on a map of the city. They are as follows:

1. Two local bus routes in Queens—Queens is one of the five boroughs of New York City; a substantial portion of the residential population commutes to Manhattan as well as to the several central business districts (CBDs), industrial, and commercial areas within Queens.
2. Two bus routes in Brooklyn—Brooklyn is another of the five boroughs of New York City (each is also a county of the state of New York). It has generally higher densities and a higher concentration of low-income areas than does Queens. It too has commercial and industrial areas, and a CBD that, if considered independently, would be the third largest in the nation.
3. One rail rapid transit line on Staten Island—Staten Island is another of the five boroughs, but it was only connected in 1964 to the others directly by the construction of the Verrazano Narrows Bridge. Previously, the only connection was by ferry. Staten Island is almost suburban in character and is currently experiencing significant growth.

Because of the diversity of economic activity, and the multiplicity of CBDs and other concentrations, it is both feasible and practical to view the city and its surrounding areas as an environment that has many transportation alternatives, including one or more feasible transit alternatives in most areas. It is this routine availability of some transit that is of interest.

Two other studies in which some of us were involved were considered to be especially relevant to the present purposes: one of express bus users and one of LIE users. The first was undertaken in 1973 for the New York City Transportation Administration (2). The second was undertaken as part of a study of improvement alternatives of the western section of the LIE, which is located in Queens (3). For convenience, the study section is shown dashed in Figure 1.

These two studies are of particular interest because they represent key alternatives to the local transit services surveyed (i.e., express bus and automobile). Further, these studies involve services that share origins and destinations with the services surveyed here.

SURVEY EXECUTION

Table 1 summarizes the basic facts of each survey: date of execution, direction, forms distributed, forms returned, survey method, crew size, and any relevant additional comments. Note the following:

1. A total of 47 247 forms were distributed, and 17 123 returns were processed;
2. The Staten Island Rapid Transit Railway Company (SIRT) survey was a major effort in logistics; 125 people were retained, trained, scheduled, and deployed for a massive one-day effort; and
3. A substantial diversity of services and areas are represented in the seven services listed.

TRIP PURPOSE AND RIDER DEMOGRAPHICS

The basic ridership of the services studied may be characterized in terms of occupation, purposes, income, gender, and age. The occupation results were somewhat ambiguous, probably due to the way in which people classified themselves. Nonetheless, some interesting patterns were noted and are discussed below.

Trip Purpose

The prime trip purposes are work and school. These encompass between 62 and 93 percent of all trips. All surveys include both peak and off-peak service, although the off-peak service on the LIE was limited.

Except for premium services (express bus and LIE), school trips make up 22-28 percent of trip purposes. Thus, one out of every four riders is going to school. Work trips account for about two out of every four riders.

A review of the trip purposes by occupation reveals the following regarding most frequent purpose:

1. About 3 out of 10 trips made by retired persons and housewives are for shopping, 2 out of 10 are for social purposes, and 2 out of 10 are for medical purposes;
2. About 8 out of 10 trips made by students are for school and 1 out of 10 are for shopping; and
3. About 8 out of 10 trips by workers were specifically for work.

The purposes of those miscellaneous trips not included in this listing were diverse.

Figure 1. Location of the five services surveyed.

Occupation and Income

The occupational distribution of users of the surveyed services matched closely those in the source population, considered in light of the destinations available along the route. Except for the lowest-income groups, who are underrepresented on the services, the ridership also reflects the income distribution of the source population.

Gender

Bus transit is startling in that it is dominated by females. This impression is confirmed by data and accentuated by comparison with other modes. Figure 2 shows the male-female gender split on the several routes and modes considered. The pattern is as follows:

1. Local buses have 60-80 percent females,
2. Express bus has close to a 50-50 split,
3. SIRT has 60 percent male, and
4. LIE traffic is dominated by male users.

SIRT is the sole rail transit line on Staten Island and is directed to Manhattan-bound traffic.

Why are there so many female riders on transit services? The data do not allow a conclusive deduction. Nonetheless, some deductions may be drawn from the following observations.

In the counties studied, zero or one automobile per household (85 percent of the cases) is the dominant condition. Bus riders actually own more automobiles per household than the source distribution, but two out of three indicate that an automobile is not available for the trip surveyed.

Women earn less than men within each occupation, even when skewing is allowed due to age distribution by gender.

Most riders express a preference for the automobile mode if it were available and feasible. The automobile mode is expensive. Figure 3 illustrates just the incremental costs of the automobile.

A plausible scenario emerges: females dominate the ridership for simple economic reasons. Where they are the sole jobholders in the household, they are less able to afford the automobile alternatives. Where they are the second jobholders in the household or using transit for nonwork purposes, there is generally only

Table 1. Summary of survey execution.

Survey	Conducted	Direction	Forms Distributed	Forms Returned	Response Rate (%)	Survey Method	Comments
B25	3/23/77	Cadmen Plaza to Fulton St.; Broadway to Jamaica Ave.	3 621	360	10	Handout on bus, mail back	Crew of 22
B46	3/30/77	Williamsburg Bridge Plaza to Kings Plaza	7 220	620	8.5	Handout on bus, mail back	Crew of 20
Q39	3/18/76	Maspeth-Ridgewood to Long Island City	2 121	598	28	Handout on bus, mail back	Crew of 20
Q65	3/26/76	College Point to Jamaica	5 476	1058	19	Handout on bus, mail back	Crew of 20
SIRT	11/17/76	Tottenville to St. George	7 236	5908 (4863 filled in)	82 67	Handout at entering station, pickup at exit station	Crew of 125; forms returned for origin and destination if not filled out
Express bus	1/73		6 285	5257	84	Handout and collection on bus	12 out of 31 surveyed in New York metropolitan area
LIE	11/77	Toward New York City, morning peak Toward Long Island, evening peak	15 288	3322	22	Mail form, mail back	Only surveyed peak-hour users

Figure 2. Gender distribution for several modes and routes.

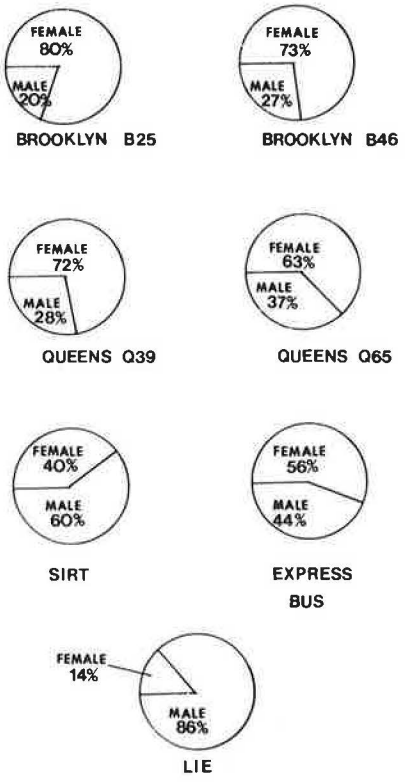
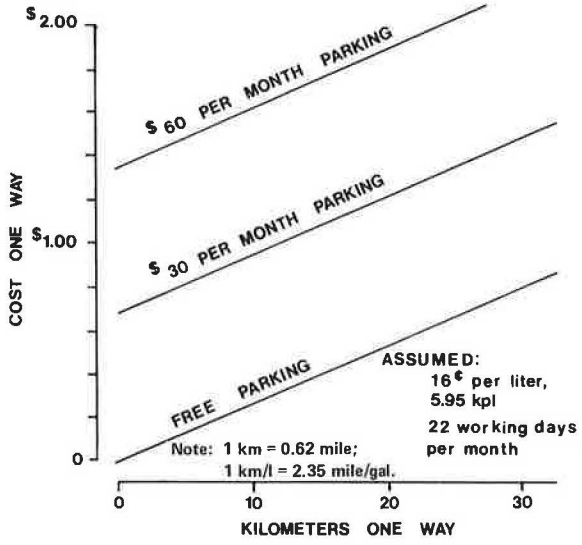


Figure 3. Gasoline and parking cost per one-way trip by automobile.



one automobile in the household, which is being used by another member or is not affordable to use. The aspect of gender in mode choice was investigated in great detail as a result of these findings. The detailed studies are reported later in this paper.

RELATION TO THE AUTOMOBILE ALTERNATIVE

Two topics of special interest relative to the automobile alternative emerged from the study:

1. Reasons for selecting transit over the automobile mode and
2. Perceived advantages of the automobile over transit and related costs.

Reasons for Selecting Transit

Transit riders were asked the reason they chose transit. The Brooklyn survey asked, "Why not use a car for this trip?" The Queens survey asked, "Why did you choose to use transit for this trip?"

Figure 4 details the results, which are summarized below:

1. The prime reason is that an automobile is not available;
2. Parking problems (not available, too expensive, or too much trouble) are generally the next-most-important factor; and
3. Transit is good is an aggregate of transit is faster and transit is more convenient; it is ranked second in Queens and third in Brooklyn.

The prime reasons for using transit relative to the impracticality of using an automobile (i.e., transit is chosen for negative, not positive reasons) even in the transit-saturated environment of New York City, where the psychological acceptance of transit could be expected to be high.

The "automobile not available" statement was checked relative to the zero-automobile households in the key origin zip codes, the most readily available relevant statistic. Figure 5 shows the relation between the two statistics. It shows the response "automobile not available" to be logical and consistent with the factual information.

The Brooklyn riders were asked specifically for the most important reason for using this bus route (as opposed to other transit alternatives). The nonstudent responses are indicated below:

Response	B25 (%)	B46 (%)
No other transit available	21	49
Comfort and convenience	40	18
Savings in travel time	17	14
Savings in travel cost	13	12
Other	9	7

These were not the order of the responses on the survey form; they are ranked in generally decreasing order for convenience.

Perceived Advantages of the Automobile and Related Costs

The survey of LIE users is of particular interest because these users are often bound for the same general areas as are the transit riders surveyed. The tunnel users are Manhattan-bound; nontunnel users are primarily bound for Queens and Brooklyn, although there is a Manhattan component that reaches Manhattan through Brooklyn via one of several East River bridges.

Asked the principal reason for using an automobile rather than public transportation or other alternative, the response was as follows:

Response	Tunnel (%)	Nontunnel (%)
Car needed during the day	26	20
Convenience worth extra time or money, if any	24	17
Next-best way takes longer	17	23
No other means of making the trip exists	15	23

Response	Tunnel (%)	Nontunnel (%)
Next-best way would cost more	4	6
Other	14	11

Clearly, the need for the car (real or perceived), the convenience, and the time are the substantial factors quoted. Cost is not a major motivation—only 5 percent of the users claim that as the reason for using the automobile (a somewhat obvious result, given that the car is virtually always the most expensive alternate).

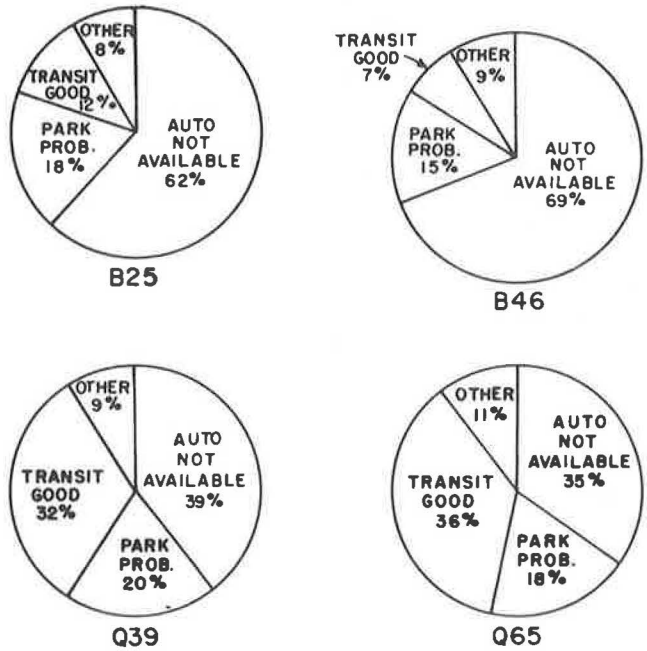
Few work-trip users drive part way, using a transit mode for the remainder of the trip (2 percent of the tunnel users, 9 percent of the nontunnel). Most do not use the vehicle at work (60 percent no use, 36 percent job-related use, 4 percent personal use).

Those who indicate that the next-best way would take longer or cost more were asked for specific amounts. Fifty percent of the respondents judge that the next-best way would take 45 or more minutes. Thus, in response to the cost item, only 5 percent of the total judge that the median (50th percentile) cost penalty would be $40-50/month.

The LIE automobile users encounter substantial expenses. They estimate the median weekly out-of-pocket costs as $15-20. Those who pay for parking pay substantial amounts: The median monthly payment for tunnel users is approximately $75; for nontunnel users, it is $50. Of those who park their vehicles and do not use them, they indicated the following:

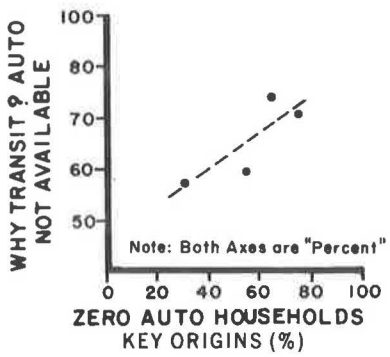
Vehicle Parked	Tunnel (%)	Nontunnel (%)
On street	15	39
In free lot	23	33
In pay lot	62	28

Figure 4. Reasons for selecting transit over automobile.



Note: Nonstudent Respondents

Figure 5. Comparison of automobile availability response with key origins.



EXPRESS BUS EXPERIENCE

The express bus experience offers two important contributions:

1. The modal preferences of the riders and
2. The meaning of comfort and convenience of the riders.

Express buses drew significant ridership immediately on initiation in the city of New York and proved to be both succesful and popular. However, the express bus survey established that 83 percent of the riders were diverted from other public transportation modes. Only 9 percent were drawn from automobile, either as a driver or as a passenger (i.e., a pooled vehicle). Some others were trips not made before, perhaps due to the prior infeasibility of the origin-destination pair in the view of the trip maker.

Figure 6 summarizes the stated reasons for using express bus over the previous method: except for Staten Island, comfort and convenience is selected in 83 percent of the responses. Staten Island is unusual in that trip lengths by public transport are generally much longer than those in other parts of the area. The express bus is the first relatively direct nonwater public transport mode. Note that in all cases travel cost is not a reason for selecting express bus, again because express bus costs more than competing transit modes.

Express bus users who indicated comfort and convenience were asked to select the two most-important factors from a list provided. These factors were later organized into distinct comfort and convenience factors by those who undertook the analysis. Figure 7 summarizes the results:

1. Comfort means having a seat and having air conditioning in the summer; comfort is about two-thirds of the phrase comfort and convenience;
2. Convenience means no transfer, close to destination, reliability of schedule, and convenience of schedule to work;
3. Safety is of greater importance in the off peak than in the peak, where assurance of a seat is of much greater interest; of course, the peak crowd itself provides some security; and
4. Cleanliness and politeness (courtesy of driver) are also elements in the comfort attribute.

This provides some insight into the phrase comfort and convenience, at least as perceived by this rider group.

FURTHER INSIGHT FROM THE GENDER PATTERN

In a related effort, one of us developed a microscopic stochastic behavioral implementation model (BIM) and exercised it in a set of case studies (4). One of the cases related specifically to the question of what gender-based model differences must exist in order to conform to the patterns observed above, specifically with regard to work trips.

Figure 6. Reasons for using express bus over previous method.

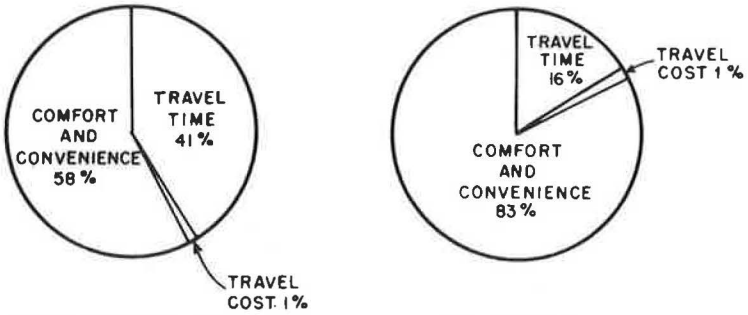
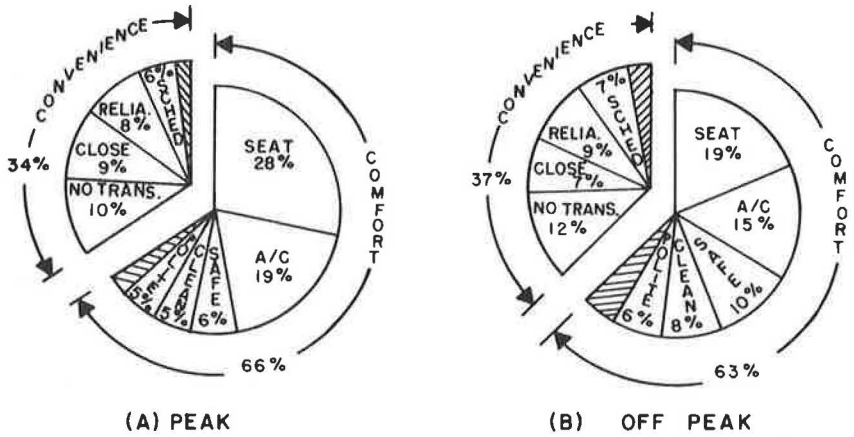


Figure 7. Meaning of comfort and convenience on express bus survey.



The Model and Decision Rule

The model can accommodate a range of decision rules and is suited to specification and modification of parameter values and variable types. A logit model of the following form was selected for our purposes:

$$P_i = J_i e^{-u_i} / \sum_{j=1}^{L} J_j e^{-u_j} \quad (1)$$

where

P_i = probability of selecting alternative i of L possible alternatives;
J_i = attractiveness of the destination, where J_i is jobs or jobs remaining if the person is home-based, and residences or residences remaining if the person is job-based in his or her decision making; and
U_i = transportation utility of alternative i.

The utility U_i can further be expressed as a function:

$$u_i = \alpha_i + \sum_{j=1}^{P} \beta_k u_i^{(k)} \quad (2)$$

where

i = an inherent utility of the prime mode on alternative i, referred to as a bias coefficient;
$u_i^{(k)}$ = the kth utility variable that contributes to the measured total utility U_i; and
k = the weight or importance associated with $u_i^{(k)}$.

The mathematical form of the above equation is not unlike that used in the historic macroscopic gravity models (5, 6) and the more recent Urban Transportation Planning System (UTPS) inclusions (7). Its use differs in several intents, however:

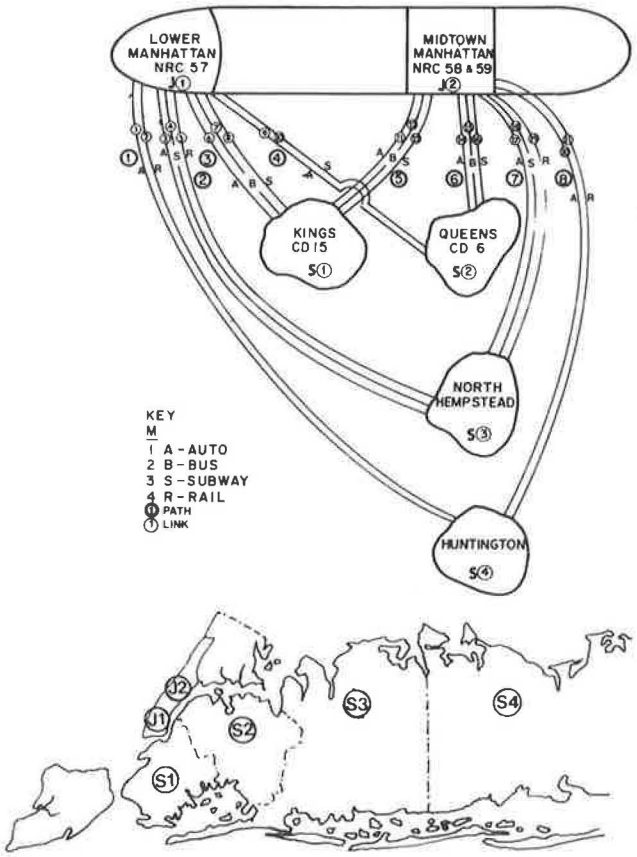
1. The model within which it is to be used is oriented toward the individual's decision process and this form can be so used,
2. The alternatives are to be various paths to the set of feasible destinations and thus imply simultaneous selection of destination and mode,
3. The coefficients J_i are keyed to job or residence opportunities, and
4. The function is used for individuals and is updated in the course of the effort (e.g., J_i may change).

It is recognized that other model forms exist and could be used. Nonetheless, given the available data and the preponderance of the generic form, it was selected for the first implementation.

Case Study

Figure 8 illustrates a set of zones in a corridor between the work centers in Manhattan and several residence zones to the east. Census fourth-count and fifth-count summarizations were available to describe basic characteristics in terms of census tracts or zip codes, respectively. To represent a closed system for modeling, journey-to-work data (8) were used to proportion the total distributions within the zones that were considered. Supplementary data were available for grouping census tracts into convenient aggregations for modeling. The Tri-State Regional Planning Commission supplied files for aggregating census tracts into minor civil divisions or planning districts (9) for residential distributions and nonresidential clusters (NCR) (10) for job-site distributions.

Figure 8. Case study 2: LIE network.



Supplementary data are also available on such matters as gender distributions within occupations (11; 12, tables 173 and 174) and pay differences by gender within occupations (12, table 176; 13).

For the specific variables in the decision model, it was decided to use a mode bias coefficient (A_1), in-vehicle travel time ($IVTT_1$), out-vehicle travel time ($OVTT_1$), and travel cost (TC_1).

These are used to compute the utility, U_1:

$$U_i = A_i + B_1 IVTT_i + B_2 OVTT_i + B_3 TC_i \quad (3)$$

The coefficients B_1 and B_2 were selected based on occupation and gender.

In a validation check, the correspondence between the predicted base condition and the existing journey-to-work statistics was good.

Replicating the Gender Pattern

Although the overall correspondence just cited was good, it did not extend to the field-observed gender variations. Figure 9 contains a summary of the percentage of males on each of three modes cited and includes the base statistics. Note that no substantial variation is evident, despite the fact that the income variation was explicitly taken into account.

Recall that the utility function is of the form:

$$U_i = A_i + \sum_k b_i \, u_i^{(k)} \quad (4)$$

The decision was made to investigate variations in the bias coefficients A_1, which differed by mode, to attempt to explain observed gender-based modal variations.

Figure 9 also illustrates the effect of introducing a bias coefficient of A = -2 and A = -3 for the automobile mode for females only. Note that a negative A leads to a disutility. Clearly, each of the values considered leads to a substantial decrease in the female share of the automobile mode, without any substantial effect on the other modes.

Because of the nature of the model, it is necessary to introduce a specific variation for the bus mode to move toward the observed pattern. This is reported in Figure 10, where values of $A_{bus,\,female} = 1$ and $A_{bus,\,female} = 2$ are introduced (the base from which they are introduced is the case in which $A_{auto,\,female} = -2$). Note that this positive A is a preference.

Figure 10 reports the effect of these last variations, which substantially reduce the male representation on the bus without substantially affecting the other mode patterns. A final case of

$$A_{auto,\,female} = -1.5$$
$$A_{bus,\,female} = 1.5$$

was introduced to attempt to refine the match to the observations. The result is also reported in Figure 10 and is a rather close match. It would not be appropriate to attempt closer values because of the inherent uncertainty in the exact data values.

It is interesting that the $A_{auto,\,female}$ value thus obtained can be translated into an equivalent travel cost increment of approximately \$2/trip (or \$4/day). This can be obtained by transforming the terms in the utility function, one into the other:

$$A_1 = b_3 \times TC \quad (5)$$

and similarly for the other terms in U_1.

It is interesting that a travel-time increment of \$4/day is approximately \$900/working year (229 days), which one may think of as the incremental annual cost of owning a second car (over and above the daily tolls and parking fees that are already taken into account in the explicitly specified travel cost for the given mode for all potential users). The concept that the $A_{auto,\,female}$ may be equivalent to purchase of a second car is worthy of note. This is particularly true in the environments tested, where single-car households are by far the most common. Needless to say, this term might not exist in a suburban or rural environment.

One may observe that the coefficient $A_{bus,\,female} = 1.5$ is equivalent to an inherent preference for the bus, which has the same utility valuation as 40 min of additional out-of-vehicle travel time. Thus, a bus trip that has 40 min more access time than an available alternative, such as subway, is equally attractive. It does raise a question, which must remain unanswered at this time, as to the motivation of this apparent preference.

Clearly, to explain observations, substantially different valuations are needed for male versus female. This study cannot resolve why those differences exist, or even quantify them in a systematic scientific survey of users. Nonetheless, it has to be observed that these variations must logically exist to explain observed phenomena and that behavioral models must explicitly take the potential for such variation into account.

CONCLUDING COMMENT

The variations herein have special interest because they include observations on several different modes. Regarding the gender-based analysis, the disaggregation by gender and occupation used in this work is not the

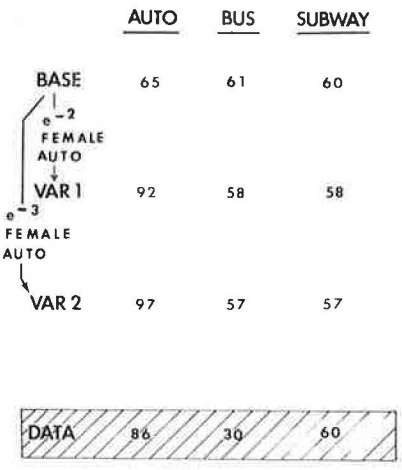


Figure 9. Percentage of males on modes with automobile bias: LIE case study.

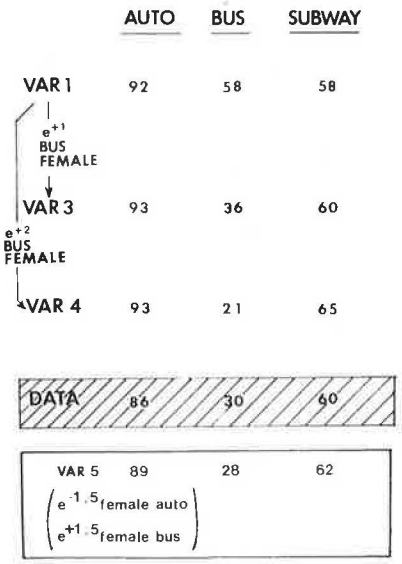


Figure 10. Percentage of males on modes with automobile and bus bias: LIE case study.

only one that could have been used and is not necessarily the most basic. Their use in the transportation field is, however, still relatively novel. One must understand that there are contributing factors under the umbrella headings of gender and occupation that can be explained in terms of the more conventional basic variables. Nonetheless, this disaggregation is useful to investigate policy questions related to what if one or more societal changes were made, such as equal pay, greater representation of women in certain occupations, or equalization of automobile availability.

In this work, the case studies included an investigation of what modifications were needed in the behavior model coefficients so as to conform to existing observations of gender representation in various modes. Other cases were executed that considered the case of equal pay for male and female. This did not introduce any substantial change in mode use by gender.

Clearly, there is an opportunity to investigate a variety of scenarios and to trace their implications. This would include the various what if questions and a consideration of how women value their travel parameters and modal choices relative to those of men.

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