A SURVEY OF THE NEW YORK CITY AIRPORT LIMOUSINE SERVICE: A DEMAND ANALYSIS

Richard de Neufville, Frank Koller, and Robert Skinner, Massachusetts Institute of Technology

An intensive, in-depth survey of a New York City airport limousine service was conducted to determine the nature of the demand for airport-access services. The principal findings of the survey are that (a) the use of the service is strongly asymmetric by direction; (b) the socioeconomic characteristics of the users are similar to those of other airport travelers; (c) a significant number of riders are essentially captive to the service; and (d) travelers arrive at the airport well ahead of flight time, 50 percent of them being there about an hour early. The modal-split model statistically calibrated from these and other observations indicates that airport-access travelers are relatively insensitive to speed but are quite sensitive to costs.

•ALTHOUGH that bundle of symptoms called the airport-access problem has been the subject of considerable discussion recently, relatively little is known in detail about the behavior of airport-oriented travelers. Even less is known about the attitudes of travelers toward alternative modes of access to the airport as reflected, for example, by the elasticity of their demand with respect to cost or travel time. The size and nature of this demand must, however, be determined fairly accurately to decide which modes of airport access should be selected for which circumstances.

The transportation systems proposed as remedies for the airport-access problem are extremely varied. Most have been directed toward speeding up the trip to or from the airport; that is, toward cutting through the congestion to the airport terminal area. Limited-access highways have been the most popular remedy, especially in the United States where municipal airport authorities derive much of their revenue from parking fees. This means of relieving delays on the way to the airport, however, seems destined to reach an upper limit in capacity, as at Kennedy International Airport in New York, for example. Other modes are thus gaining in favor. Special access links by railroad have been under consideration for airports in London, Hamburg, New York, and Tokyo. Subway extensions have been built in Brussels, London, and Cleveland and are being recommended for San Francisco and possibly Chicago. An exclusive bus right-of-way was programmed for Kansas City. The connection to the airport, as a relatively small yet complete system, also appears as a plausible testing ground for technological innovations. The tracked air-cushion vehicle (TACV) is, for instance, proposed for Los Angeles. Solutions designed to improve access speed are those that operate not only on the ground but also in the air. Helicopter and short takeoff and landing (STOL) services have been tried in New York, San Francisco, and Los Angeles and are proposed for Washington, D. C. The relative usefulness of any of these technologies will depend in great part on how the public might choose to use them.

Demand models are, therefore, needed to estimate the possible behavior of the traveling public. To be accurate, these models should explicitly reflect the factors that cause travelers to prefer one mode over another. The models should thus be causal or, equivalently, behavioral. The parameters of such behavioral models can be calculated either by using disaggregated data on individual trips or, at some loss of precision

Sponsored by Committee on Passenger and Freight Transportation Characteristics and presented at the 50th Annual Meeting.

but also at a significant reduction in cost, by using aggregated data on groups of trips. The choice between aggregate and disaggregate models has to be governed by the purpose for which the model will be used and by the resources available. For this first analysis done in 1970 of the limousine airport-access service, an aggregate model was used because it was, in part, to predict the overall effect of proposed fare adjustments. The follow-on analysis of 1971 has, however, been using a disaggregate approach.

To determine the aggregate modal-split behavior of airport passengers, an in-depth survey was carried out in the New York City region in 1970 (1), and a modal-split model was calibrated (2). The results of the survey expand considerably on the findings of previously published surveys (3, 4, 5, 6, 7, 8, 9) for Washington, New York, Philadelphia, Cleveland, Los Angeles, and Connecticut and are corroborated by the preliminary results of the surveys conducted at Salt Lake City (10). The modal-split analysis suggests that the airport traveler, in contrast to other travelers such as commuters, is fairly indifferent to time savings but relatively sensitive to costs.

NATURE OF SURVEY

The research strategy capitalized on the active support of a local airport-access service, the Wilder Transportation Company, that was interested in exploring the desirability of satellite check-in facilities throughout suburban New York City. Its cooperation and the particular features of the limousine service it operates made it possible to administer an extensive, detailed survey successfully.

The Wilder Transportation Company operates a limousine service between Westchester County, New York, and LaGuardia and Kennedy airports on Long Island. Its principal route is about 25 miles long and runs north from the airports, crosses the Long Island Sound, runs northeasterly along the coast, and then traverses west across Westchester County. Because of the geography, all passengers traveled between two fixed points some 30 min apart—New Rochelle, the last boarding station, and LaGuardia, the first airport.

The limousine passengers were thus captive for an extended period and could be, and were, asked to complete a long questionnaire. Because they passed the control points in small numbers, every precaution could be taken to ensure a good response and, in fact, a questionnaire return rate of about 90 percent was achieved.

The survey questionnaires were designed to find out how the passengers evaluated the limousine service in contrast to other modes and why they might choose one mode over the others. The questionnaires were specifically intended to define how the passengers used the access system: how, how long, and how far they traveled to and from the limousine boarding stations; how long they waited there; and how soon before departure they arrived at the airport. In general, little has been known about these factors, and it has consequently been impossible to accurately calibrate modal-split models for airport access.

To determine how the limousine passengers compared with other airport travelers, the questionnaire included many of the general social, economic, and demographic questions usually featured in other airport-access surveys. In particular, they inquired as to the passenger's age, sex, income, place of residence, trip purpose, and destination. In this sense they were identical to the Port of New York Authority surveys (4) so that a direct comparison could be established between the use of the limousine service and the use of the other modes reported by the Port of New York Authority.

To account for the different circumstances that face the departing and arriving passengers, two questionnaires were developed, one for each direction. As indicated in the basic report (1), there was a one-to-one correspondence between questions on the two questionnaires, but in some cases a question on one asked a passenger to estimate some quantity that he has just experienced, such as travel time, while the corresponding question on the other form asked him to estimate a quantity he has yet to experience. In all, 33 questions were asked.

The survey was run in January 1970 following a pretest in December. The passengers were canvassed on a Thursday and Friday, because the resources available were not sufficient to allow a survey of more than 2 days. These days appear representative because limousine traffic Monday through Thursday is reasonably similar, Fridays

TABLE 1

WESTCHESTER COUNTY TRAVELERS USING LIMOUSINE SERVICE TO AND FROM AIRPORT

Trip Direction	Residents		Nonresidents		Percent of Total Volume
	Number	Percent	Number	Percent	
To airport	85	40	128	60	40
From airport	208	73	78	27	60

and Sundays are traditionally the two big days, and Saturday is a slow day. A few more than 500 passengers were asked to participate in the survey and 499 responses were obtained for a composite response rate of about 90 percent.

SURVEY RESULTS

The more striking self-evident results of the survey are described in this section. An exhaustive tabulation of the data can be obtained from the M. I. T. Civil Engineering Systems Laboratory (1). The modal-split analysis developed from the data is presented in a subsequent section.

Asymmetry of Use of Airport-Access Service

It appears that there is a strong asymmetry in the use of the limousine service. The composition and desire lines of the travelers going to the airport differ substantially from those of the travelers coming from the airport. This is given in Table 1.

The demand for service from the New York airports is approximately half again as large as the demand for service to the airport. The increased demand for public service away from the airport is overwhelmingly attributable to residents, of whom there are more than twice as many going from the airport as to it. This finding is corroborated by the Baltimore-Washington airport-access survey (5, 11), which found that about twice as many people used the limousine service away from the airport, and by the study of Los Angeles (8), which found there were nearly 20 percent more.

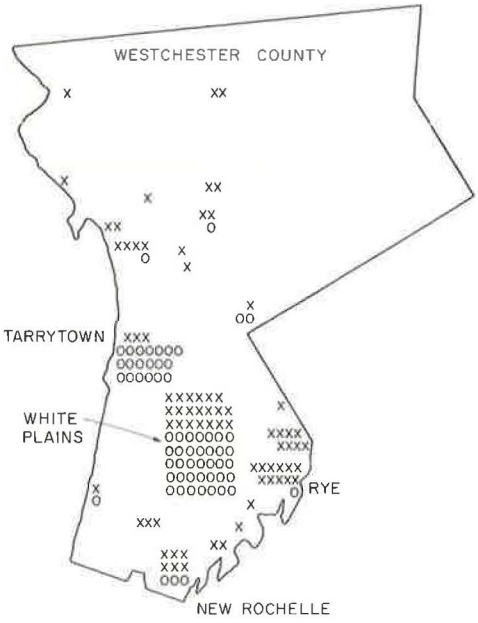

Figure 1. Trip origins of limousine passengers going to the airports (X = resident, 0 = nonresident).

The pattern of desire lines between the airport and the suburbs also differs considerably according to the direction of the trip. As shown in Figures 1 and 2, the trip ends are considerably more dispersed for trips away from the airport. As shown in Figure 2, many of these dispersed trip ends are caused by residents relatively near the airport (in New Rochelle, for example) who appear to have gotten to the airport by some other form of public conveyence or, most likely, by car.

These observations about the asymmetry of travel patterns on the common carrier airport-access service are not necessarily surprising. It is entirely plausible to argue that passengers arriving at an airport are more likely to be unsure of their plans (because they were not certain when their business elsewhere might end, for example) and therefore to be unwilling to call on their family or friends to pick them up. These same people

might well, however, let themselves be taken to the airport for a specific flight. The asymmetry in choice of mode may, in fact, be caused by an asymmetrical perception of the availability of the family car. It may be "available" for taking the husband to a specific flight, but be "unavailable" for being parked at the airport for several days or for picking him up at the rush hour or when his time of return is uncertain. This question of changing availability is being explored in the 1971 survey.

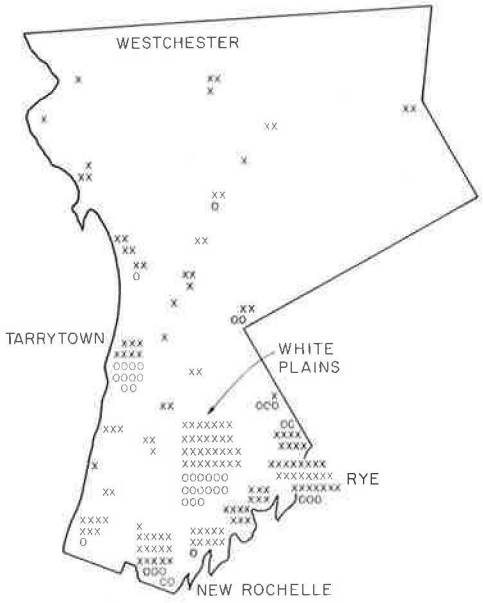

Figure 2. Trip ends of limousine passengers arriving from the airports (X = resident, 0 = nonresident).

Characteristics of Limousine Passengers

The social and economic characteristics of limousine passengers do not, apparently, differ significantly from airline passengers as a whole. The evidence seems to refute the suggestion that particular groups of users with distinguishing demographic features might choose to use the limousine for airport access. By analogy with urban transportation, where women are dominant users of public transportation, it has been hypothesized that limousine users would also represent particular groups such as women, older people, and less affluent people. These hypotheses appear to be false.

The similarity between limousine and air passengers as a whole is given in Table 2. Although the Port of New York Authority survey included Newark Airport and studied only departing domestic passengers (4), its results still appear suitable for comparison with the Wilder survey. The two groups of passengers appear to be quite similar on the basis of the data obtained. The Wilder passengers do seem to have considerably higher incomes than New York passengers in general, even when the inflation between 1963 and 1970 is considered. But Westchester is a high-income area with respect to New York City as a whole. Thus, there does not seem to be any radical social or economic differences between limousine and air passengers as a group.

Captive Riders

A large share of the limousine passengers may be considered "captive" to the common carrier. These passengers either do not have anyone whom they could ask to pick them up or lack confidence in their ability to drive to their destination, or both. They, thus, do not have many effective alternatives except taxis, which rapidly become too expensive for long suburban trips.

Of those travelers who are not Westchester residents traveling on business, for example, 70 percent felt that there was no one they could ask to pick them up and 63 percent

TABLE 2
CHARACTERISTICS OF AIR TRAVELERS

Air Travelers	Male Travelers (percent)	Travelers on Business (percent)	Travelers 25 to 55 Years Old (percent)	Travelers With Incomes Over $20,000 (percent)
All[a]	76	63	70	34
Using limousine service[b]	74	72	68	61

[a]1963 survey by Port of New York Authority (4).

[b]1970 survey taken on Wilder limousines and reported here.

did not fell that they could find their way by car. Most members of this group, which constitute a large fraction of all the limousine passengers or about half of the departing passengers, are in a sense captive riders. These "captive" riders are generally rich, vigorous men: 51 percent have incomes greater than $20,000; 85 percent are male; and 83 percent are in the 25 to 55 age bracket.

The riders captive to the limousine service are not at all like the poor, the old or very young, or the predominantly female passengers who are captive to urban public transportation. There is little evidence on this basis to suggest that common-carrier airport access is likely to disappear as the urban bus services tend to disappear, as incomes rise, and as people can afford better transportation. The airport-access common carrier, the limousine in particular, appears to offer a service (i.e., reliable conveyance to a destination) for which a ready substitute is not available.

Awareness of Service

Many potential limousine passengers appear to be unaware of the existence of the service. This ignorance, to the extent that it exists, precludes the common-carrier limousine service from consideration as a viable alternative transportation mode. Efforts to make a service more attractive and to develop a more favorable modal split will be in vain so long as people do not know of the service.

Relatively few nonresidents appear to know about the limousine service. As shown in Figure 3, nonresident limousine passengers mostly appear to have learned about the service within the last year even though Wilder has been active for 9 years. These observations indicate, as can be demonstrated theoretically (1, 12), that diffusion of the knowledge of the limousine service has only begun to tap its potential.

Conversely, it appears that most potential limousine passengers who live in Westchester are aware of the local limousine service. Figure 4 shows that the percentage of passengers who learned about the service in any one period is fairly constant. This is what one would expect for a population that has significant mobility (10 to 20 percent of population moves each year) and that was saturated with information about the service.

This information suggests that there is considerable ignorance about this airport-access mode and, presumably, about similar common carriers. To some extent, yet undetermined, this ignorance leaves a significant market untapped. Removal of this ignorance, as by national advertising of the airport-access services, would thus seem likely to strengthen the demand for airport-access services.

Early Arrivals at the Airport

Air travelers customarily arrive at the airport far in advance of their flight. As a rule, about half of the passengers arrive at the airport an hour before flight time. Some of this lead time is required for ticketing and baggage check-in processes, but the rest is the risk time passengers allow for unforeseen delays and congestion. This risk time is on the order of 30 min on the average.

The cumulative percentage of limousine travelers who have arrived at the airport at any given time before departure

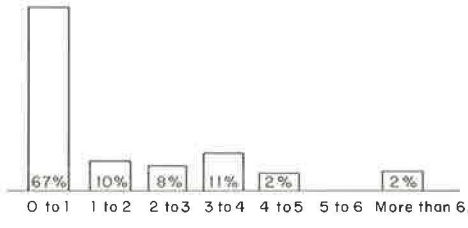

Figure 3. Length of time that nonresident limousine passengers have known about service.

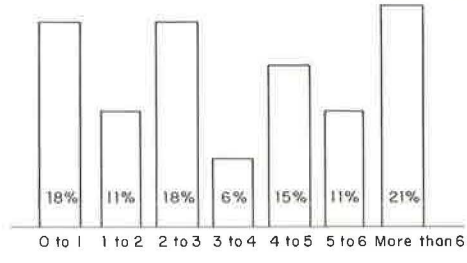

Figure 4. Length of time that resident limousine passengers have known about service.

is shown in Figure 5. Not only do half of the travelers arrive more than 50 min early but also a significant number arrive 2 hours or more in advance. These data are almost identical, both in shape and extent, to the observations made by Karash on passengers by all modes at Boston (13), to the preliminary information available from the survey of all departing air travelers at Salt Lake City (10), and to the analysis of Avi-Itzhak and Mandelbaum at Lod Airport in Israel (14).

One particular exception to the general rule that 50 percent of the passengers arrive 50 min or more before flight time should be noted. Observations by Robert Simpson of the M.I.T. Flight Transportation Laboratory indicate that commuters as a class time their arrivals much more closely. In particular, the mean time of arrival at the gate on the early morning Eastern Airline Shuttle Service from Boston to New York or Washington is much closer to 10 min than to 50 min. These interesting results taken on a specific kind of client need not, however, concern us here.

MODAL-SPLIT ANALYSIS

A modal-split equation of the form

$$\text{Volume} = (\text{constant}) \times (\text{price})^{-\alpha} \times (\text{travel time})^{-\beta} \qquad (1)$$

was calibrated by least-squares regression. Multiplicative share models of this type are conventional for the estimation of aggregate demand for services (15), and their use has been demonstrated for practical transportation problems by MacAvoy and Sloss (16).

For this initial analysis, an aggregate model (i.e., one that attempts to predict how groups of persons will behave in the aggregate) was selected because it was explicitly desired to estimate the public's response to proposed fare changes. For this purpose and in this situation, it appeared to be more economical and more cost-effective to use the aggregate model. In other situations a disaggregate model would be appropriate. A disaggregate model will, in fact, be used to analyze the data collected in the follow-up survey conducted in January 1971 and to determine the effect of automobile availability or mode choice.

The modal-split Eq. 1 was chosen as an appropriate aggregative model because it appears to provide the best representation of our intuitive and theoretical sense of how volumes of traffic would vary as price changes. First, the negative exponents on the variables cause the predicted volume to vary nonlinearly just as theory suggests that the demand curve should (Fig. 6). Second, the multiplicative nature of Eq. 1 reflects the concept that the effect of changes in one variable depends on the level of the others. The effect of a $1.00 rise in fares on the limousine, for example, depends on whether the travel times are good or already marginal.

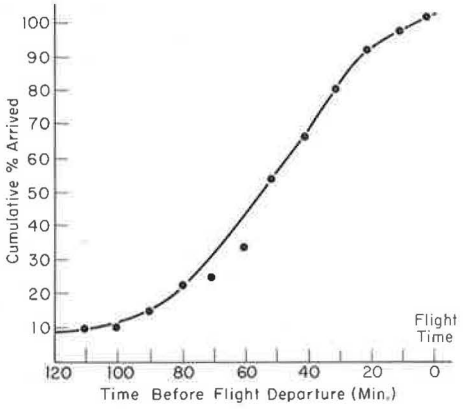

Figure 5. Cumulative percentage of limousine passengers who arrived at airport a given time before scheduled flight departure.

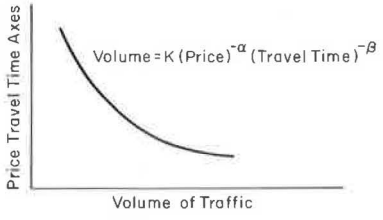

Figure 6. Nonlinear demand curve for transportation.

A multiplicative relationship such as Eq. 1 is just as easy to calibrate as the simpler, less representative, linear equations. Indeed, Eq. 1 can be made linear by the simple expedient of taking the logarithms of all variables:

$$\log(\text{volume}) = \log(\text{constant}) - \alpha(\log \text{price}) - \beta(\log \text{travel time})$$

The desired coefficients and constant can then be estimated directly by regression in the usual way.

Avoiding the Identification Problem

One of the reasons the limousine airport-access mode was chosen for detailed examination is that it avoids the identification problem, which inherently plagues many other statistical estimations of transportation demand and modal split. The identification problem arises, in essence, when the cost of a trip varies with the amount of congestion or demand for a service (as shown by a volume-delay curve) and also when the demand varies with price (Fig. 7). This situation, which is pervasive in congested urban transportation, can make it impossible to accurately estimate modal split (17, 18).

The identification problem is avoided in the estimation of the modal split for common-carrier airport-access services, such as for the limousine, because of the special nature of the transportation demand and supply. First, the passengers are all directed toward one goal. It is reasonable to assume that they each are similarly sensitive to changes in price and travel time; that is, that they have a common demand curve. Second, the fares are fixed by regulation of the Public Utilities Commission, and the travel times along the expressways are essentially independent of the number of passengers carried. The supply curves, thus, "trace out" the demand function (16). The observations on the number of passengers carried at different points, with different comparative fares and travel times between the limousine and other modes, make it possible to identify the demand and the related modal-split equation. The modal-split equation for the limousine airport-access service, therefore, has a high probability of being more accurate than other urban modal-split models.

Avoiding the Collinearity Problem

Whenever two or more explanatory variables are closely correlated, their separate effects on the dependent variable cannot be distinguished. It is then impossible to accurately estimate the parameters of a modal-split equation. This is the collinearity problem.

Collinearity between explanatory variables is pervasive in transportation. For practically all forms of transportation, the price and travel times are closely correlated with each other; frequently both are simple multiples of distance. The prices and travel times of competing modes over the same distance are similarly collinear with each other. Collinearity is probably a prime reason for the inaccuracies and conflicts among different modal-split equations.

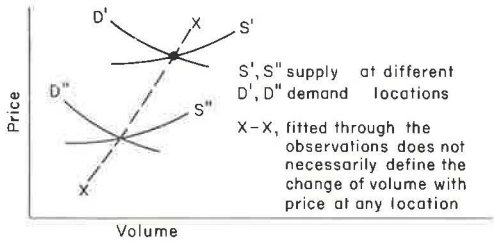

Figure 7. Fitted line to series of observations on supply and demand.

Extensive collinearity also exists between the variables that govern the modal split between airport-access modes. Table 3, for instance, gives the degree of collinearity between characteristics of the limousine and a competitive airport-access service. Most of the possible explanatory variables have coefficients of partial correlation greater than R = 0.50 and are highly collinear. A similar situation was found by Rassam, Ellis, and Bennet in their study of Washington (11).

The highly collinear variables should not be used together in a modal-split equation. The joint presence of collinear

variables in an equation tends to render any estimate of the parameters meaningless. To demonstrate this, one need only substitute one collinear variable for another and observe that equally good modal-split equations could be obtained with completely different coefficients of calibration. This ambiguity is strongest when the coefficient of correlation between explanatory variables is near 1.0. The confusion of collinearity problems is avoided by using variables whose mutual R is less than 0.50.

TABLE 3

CHARACTERISTICS OF AIRPORT-ACCESS SERVICE BY LIMOUSINE AND BY TAXI

Variables Compared	Coefficient of Correlation, R
Price of limousine and price of taxi	0.60
Price of limousine and travel time of taxi	0.38
Price of limousine and travel time of limousine	0.59
Price of taxi and travel time of limousine	0.92
Price of taxi and travel time of taxi	0.81
Taxi price/limousine price and limousine time/taxi time	0.81
Limousine price/taxi price and limousine time/taxi time	0.38
Travel time of limousine and travel time of taxi	0.62

Calibration of Modal-Split Equation

The modal-split equation determining the market share of the limousine service was calibrated for nonresident business men going to the airport. These passengers faced two public service alternatives—the limousine and the taxi. The model-split equation calibrated was defined in terms of the prices and travel times of the limousine and taxi service. So that collinearity problems are avoided, ratio forms were used to define the share of the traffic obtained by the limousine service.

$$\frac{\text{Volume by limousine}}{\text{Total volume}} = K\left(\frac{\text{price of limousine}}{\text{price of taxi}}\right)^{\alpha}\left(\frac{\text{travel time of limousine}}{\text{travel time of taxi}}\right)^{\beta} \quad (2)$$

Data on the total volume of traffic from Westchester to each airport were obtained from the most recent (1967-68) but yet unpublished domestic air-passenger survey of the Port of New York Authority. The 2-year difference between the Port of New York Authority data and the Wilder survey data was judged not to represent a serious problem because neither the nature nor the size of the market had changed to any great extent. The Port Authority had data by ZIP code zone, and the limousine survey data were aggregated to match. The data for taxi times and costs were estimated separately for each zone by examination of their fares and of the routes to the airports.

The final form of the modal-split model was calibrated as

$$\frac{\text{Volume by limousine}}{\text{Total volume}} = 0.15\left(\frac{\text{price of limousine}}{\text{price of taxi}}\right)^{-2.33}\left(\frac{\text{time by limousine}}{\text{time by taxi}}\right)^{-1.23}$$

where R = 0.59, which defines the share of the airport-access market to be obtained by the limousine service. The t-tests showed that each of the coefficients were significant at the 95 percent level of confidence. From a statistical viewpoint, this modal-split model is satisfactory.

Discussion of Modal-Split Equation

The analysis indicates that limousine passengers are almost twice as sensitive to price changes as to changes in travel times. This is a fairly important result, because it is frequently assumed that businessmen, for whom this model was calibrated, are relatively insensitive to price because they are on expense accounts but are quite conscious of travel time because they are in a hurry. This assumption that the businessman is insensitive to prices appears to be untrue in this case.

Perhaps the major reason that these airport-access passengers are relatively insensitive to travel time is that they plan to arrive at the airport well before the scheduled

flight time in any case. Even fairly large savings in access time, about 15 min or so, might then not be of any particular advantage to them.

Conversely, the cost sensitivity of airport-access passengers coming from the suburbs can possibly be explained by the distance to be traveled. The costs of getting to the airport from Westchester or a similar distant suburb are significant, ranging from 7 to 20 dollars, and already represent a large fraction of the cost of a medium-range plane fare. It is then quite understandable that the businessmen traveling long distances to the airport are sensitive to costs, even though they might not be sensitive to the small cost differences they might encounter between center-city transportation alternatives.

TABLE 4

COMPARISON OF PRICE AND TRAVEL TIME SENSITIVITY OBTAINED FROM THREE SURVEYS

Travel	Ratio of Price	Ratio of Travel Time
Airport access	-2.33	-1.23
California intercity[a]	-2.34	-1.75
West Virginia intercity[b]	-2.184	-1.435

[a]de Neufville and Stafford (17, Eq. 7).

[b]de Neufville and Stafford (18, Model B).

Because the airport-access system has not received detailed consideration, it is only possible to compare the analysis reported here to different kinds of studies. It would appear that the airport-access trip resembles intercity travel more than intracity travel. Intercity travel tends, like airport-access trips, to be irregular and to cost significantly more than the regular commute to work. A comparison of the other results that are available, such as those obtained by Quandt and Baumol for the travel patterns between 20 cities in California (19), those obtained by Yu for intercity travel in West Virginia (20), and those obtained for this airport-access study, is then encouraging because the results are closely similar (Table 4). The parameters of the disaggregate model estimated by Rassam, Ellis, and Bennett likewise suggest that the travelers using the limousine are much more sensitive to price than to travel time (11). The modal-split model appears to be satisfactory, as a preliminary estimate, from both a statistical and an analytic viewpoint.

SUMMARY

The survey and analysis of the demand for airport-access transportation, based on an in-depth examination of a limousine service, indicate the following:

1. The use of the service is strongly asymmetric in that it carries many more people, especially residents, away from the airport than to it.
2. The social and economic characteristics of limousine passengers do not differ appreciably from those of all other airport travelers.
3. A significant percentage of the riders, especially the nonresidents, are captive to the public service to the extent that they would have great difficulty in going any other way.
4. It can also be inferred that many potential riders from out-of-town are unaware of the service.
5. Many travelers arrive at the airport well ahead of flight time, and 50 percent of them arrive about an hour ahead of time.
6. This risk time suggests that longer distance airport-access travelers are relatively insensitive to speed but quite sensitive to costs, as indicated by the following calibrated modal-split equation:

$$\text{Proportion of travelers going by limousine} = 0.15\left(\frac{\text{price of limousine}}{\text{price of taxi}}\right)^{-2.33}\left(\frac{\text{travel time by limousine}}{\text{travel time by taxi}}\right)^{-1.23}$$

These conclusions were tested in January 1971 in a new survey. Because the Wilder Transportation Company instituted fare increases ranging from 8 to 19 percent in October 1970, we have had a specific opportunity to see how accurately the calibrated

quation can predict the results of management intervention. The results of this re-urvey will be reported in the summer of 1971. The new analysis also intends to test, y means of a disaggregate analysis, the nature and size of the effect of automobile vailability on the use of public transportation.

REFERENCES

1. Skinner, R., and Koller, F. A Survey of Airport Limousine Passengers. Dept. of Civil Engineering, M.I.T., Cambridge, Vol. 6, R70-46, Aug. 1970.
2. Koller, F., and Skinner, R. Modal Split Models for Airport Access. Dept. of Civil Engineering, M.I.T., Cambridge, Vol. 7, R70-47, Aug. 1970.
3. A Survey of Local Origins and Destinations of Users of Washington National Airport. Human Sciences Research, Inc., HSR-RR-61/5-MS-6, Feb. 1961.
4. New York's Domestic Air Passenger Market. Aviation Dept., The Port of New York Authority, May 1965.
5. Washington-Baltimore Airport Access Survey. Abt Associates, Cambridge, Mass., May 1968.
6. Corradino, J. C., and Ferreri, M. G. In-Flight Origin-Destination Survey at Philadelphia International Airport. Highway Research Record 274, 1970, pp. 35-43.
7. Chann, I. K., and Ashwood, J. E. Connecticut Air Passenger Characteristics. Traffic Quarterly, April 1970, pp. 207-218.
8. Los Angeles International Airport Survey of Scheduled Air Passenger Market. Landrum and Brown, Cincinnati, Vol. 1 and 2, March 1968.
9. Survey Results, Cleveland-Hopkins Airport Access Study. Cuyahoga County Regional Planning Commission, Ohio, June 1970.
10. Whorf, R. P. Salt Lake City Transportation Interface System Study. Transportation Research and Planning Office, Ford Motor Co., Dearborn, Mich., Vol. 2 (draft), 1970.
11. Rassam, P. R., Ellis, R. H., and Bennett, J. C. The N-Dimensional Logit Model: Development and Application. Peat, Marwick, Mitchell and Co., Washington, D. C., 1970.
12. Ayres, R. U. Technological Forecasting. McGraw-Hill, New York, 1969.
13. Karash, K. H. Analysis for the Design of Baggage Handling Systems at Airports. Dept. of Civil Engineering, M.I.T., Cambridge, Vol. 1, R70-30, June 1970.
14. Avi-Itzhak, B., and Mandelbaum, M. Mathematical Models for Outgoing Traffic Flow in an Airport Terminal. Operations Research, Technion, Israel Institute of Technology, Haifa, Statistics and Economics Mimeograph Series 14, Feb. 1968.
15. Kraft, G., and Wohl, M. New Directions for Passenger Demand Analysis and Forecasting. Transportation Research, Vol. 1, 1967, pp. 205-230.
16. MacAvoy, P. W., and Sloss, J. Regulation of Transport Innovation. Random House, New York, 1967.
17. de Neufville, P and Stafford, J. The Identification of Transportation Demand. ASCE, Prep. at 1261, July 1970.
18. de Neufville, R., and Stafford, J. Systems Analysis for Engineers and Managers. McGraw-Hill, New York, 1971.
19. Quandt, R. E., and Baumol, W. J. The Demand for Abstract Transport Modes: Theory and Measurement. Jour. Regional Science, Vol. 6, No. 2, 1966, pp. 13-26.
20. Yu, J. C. Demand Model for Intercity Multimode Travel. Transportation Engineering Jour., Proc. ASCE, Vol. 96, No. TE2, May 1970, pp. 203-210.