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Volume Author/Editor: Reuben Gronau

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Chapter Author: Reuben Gronau

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THE ESTIMATION OF THE PRICE OF TIME AND THE DEMAND FOR AIRLINE TRANSPORTATION

AS DEMONSTRATED in the last chapter, crude data can go a long way in interpreting the broader outlines of the transportation market. Timetables and fare schedules provide enough information to explain the effect of income, of the purpose of a trip, and of distance on the modal choice, and to yield a rough estimate of the relationship between the price of time and hourly earnings. The prediction of the future shape of the transportation market calls, however, for a more sophisticated approach based on the estimation of the traveler's demand and his price of time.

Assume that the quantity of trips to destination j demanded by traveler $i(X_{ij})$ is an exponential function of the trip's price (Π_{ij}) and the traveler's income (Y_i),

$$X_{ij} = B_j \Pi_{ij}^{\beta_{1j}} Y_i^{\beta_{2j}} e^{u_{ij}}, \tag{5.1}$$

where u_{ij} denotes the stochastic disturbance term. As explained in Chapter 3 the income variable Y_i serves either as a measure of the traveler's ability to pay for the trip or as a proxy for his skills. The price of the trip Π_{ij} varies both with the destination of the trip and with the traveler's price of time. Rewriting the demand function in a logarithmic form (natural log) yields a linear function,

$$\log X_{ij} = \beta_{0j} + \beta_{1j} \log \Pi_{ij} + \beta_{2j} \log Y_i + u_{ij}, \tag{5.2}$$

where $\beta_{0j} = \log B_j$. Unfortunately, this function's parameters cannot be estimated directly since one of the independent variables, price, is unobservable; the price of time being unknown,

$$\log X_{ij} = \beta_{0j} + \beta_{1j} \log (P_j + K_i T_j) + \beta_{2j} \log Y_i + u_{ij}.^1 \quad (5.3)$$

Economic theory suggests that the price of time and earnings are directly related. It does not specify, however, the exact nature of this relationship. The value the traveler places on his time may change at a faster rate than his hourly earnings, it may increase with the time of traveling, and may depend on the mode used. Adopting the simplest set of assumptions, I assumed that the price of time is proportional to hourly earnings (W) and is independent of the elapsed time and the mode of travel,

$$K_i = kW_i, \quad (5.4)$$

Equation (5.3) can, therefore, be written

$$\log X_{ij} = \beta_{0j} + \beta_{1j} \log (P_j + kW_i T_j) + \beta_{2j} \log Y_i + u_{ij}. \quad (5.5)$$

The demand functions for trips to various destinations differ with the "attractiveness" of the point of destination, the "attractiveness" being determined by factors affecting the demand for visits, the degree of substitution between trips and related inputs, the price of these inputs, and the share of the trip's price in the total costs of the visit. Assuming that these factors affect only the level of the demand curves but not the demand elasticities, (5.5) can be rewritten

$$X_{ij} = \beta_{0j} + \beta_1 \log (P_j + kW_i T_j) + \beta_2 \log Y_i + u_{ij}. \quad (5.6)$$

When the attractiveness factor (G_j) is measurable and additive, one can rewrite equation (5.6),

$$X_{ij} = \beta_0 + \beta_1 \log (P_j + kW_i T_j) + \beta_2 \log Y_i + \beta_3 \log G_j + u_{ij}. \quad (5.7)$$

[1]Note the difference between this formulation and a model that specifies that the fare (P) and time (T) elasticities are constant

$$\log X_{ij} = \beta_{0j} + \beta_{1j} \log P_j + \beta_{2j} \log T_j + \beta_{3j} \log Y_i + u_{ij}.$$

(See, for example, Samuel L. Brown, "Measuring the Elasticities of Air Travel," 125th Annual Meeting of the American Statistical Association, September 1965.) Equation (5.3) is nonlinear in log P and log T.

Substituting in equation (5.6) arbitrarily chosen values of k and picking the value that yields the highest explanatory power, one can obtain the estimate of both the price and income elasticities (β_1 and β_2, respectively), as well as the ratio of the price of time to hourly earnings (k).[2]

Information on the population's traveling habits can be obtained in two ways: (a) a ticket count, and (b) a survey based on personal interviews. The major drawback of the first method is its inability to provide any additional information on the traveler's and the trip's characteristics other than the trip's destination. In particular, this method does not disclose any information on the traveler's income and the purpose of the trip. An attempt to incorporate these two variables in the demand analysis calls, therefore, for the use of some auxiliary data, data that are necessarily inaccurate or unavailable. In order to avoid these problems, it was decided to base the analysis on interview data.

One of the more detailed sources of interview data is contained in the Port of New York Authority's survey.[3] The survey covered a representative sample of all outbound flights of scheduled airlines departing from the three New York airports during the twelve months ending March 29, 1964. The cluster sample included 1,358 randomly chosen flights. Information concerning 22,263 passengers on these flights was processed, representing 0.27 per cent of all outbound passengers from New York in the same period. Each of these passengers (twelve years of age or older) was asked to fill out a questionnaire regarding his socioeconomic characteristics (i.e., age, sex, education, profession, industry, family income, and place of residence), his flight experience (i.e., the number of air trips in the last twelve months, and the date of his first airline flight), and the present trip's characteristics (i.e., origin and destination, purpose, duration, the class of the ticket, and the mode of arrival at the airport). The survey provides no information on the

[2] Had we assumed that the demand function is linear

$$X_{ij} = \beta_0 + \beta_1\Pi_{ij} + \beta_2 Y_i + \beta_3 G_j + u_{ij},$$

we could estimate

$$\begin{aligned} X_{ij} &\doteq \beta_0 + \beta_1(P_j + kW_iT_j) + \beta_2 Y_i + \beta_3 G_j + u_{ij} \\ &= \beta_0 + \beta_1 P_j + \beta_1 k W_i T_j + \beta_2 Y_i + \beta_3 G_j + u_{ij} \\ &= \beta_0 + \beta_1 P_j + \gamma W_i T_j + \beta_2 Y_i + \beta_3 G_j + u_{ij}, \end{aligned}$$

where $k = \gamma/\beta_1$.

[3] *New York's Domestic Air Passenger Market, April 1963 through March 1964,* New York, May 1965.

characteristics of the different trips taken by a given traveler, but rather a detailed description of the properties of each air passenger-trip.

The dependent variable in our model describes the number of trips to a given destination taken by an individual (or a household) with a given income. The first step in adapting the Port of New York Authority data to our model calls, therefore, for the classification of the information on passenger-trips by the traveler's income and destination. In order to reduce the amount of random "noise," we focused our attention on the 38 most heavily trafficked routes originating in New York, comprising a subsample of 13,822 nontransfer passenger-trips. The Port of New York Authority questionnaire distinguished among ten income groups. The classification by income and destination, therefore, results in 380 observations, each describing the total number of air trips to a certain destination taken by travelers belonging to a given income group. To obtain a measure of the trips per family, one has to divide these figures by the number of potential travelers. Assuming that all travelers to a certain destination reside either in New York's or in the destination's Standard Metropolitan Statistical Areas (transfer passengers being excluded from the subsample), the number of passenger-trips in each cell was divided by the number of families belonging to that income class in the two SMSAs.[4] This procedure was followed separately for business and nonbusiness trips to produce two dependent variables—the number of business trips per family and the number of personal trips per family.

A second variable based on the Port of New York Authority data is the income variable. The questionnaire distinguished among 10 income groups: 0–3,000; 3,000–5,000; 5,000–6,000; 6,000–7,000; 7,000–10,000; 10,000–11,000; 11,000–15,000; 15,000–20,000; 20,000–25,000; and 25,000+ dollars. The groups' midpoints were chosen as the representative incomes of those passengers whose income did not

[4] The information on the number of families classified by income and SMSA of residency was obtained from the 1960 Census, *1960 Census of Population,* Vol. 1, *Characteristics of the Population,* Table 76. Information on families, rather than individuals, was employed because of the availability of a more detailed income distribution for this variable. A Pareto distribution was fitted to the Census data in those cases where the income classification of the Census and the Port of New York Authority survey did not coincide. It was assumed that the income distribution in each SMSA and the population distribution among SMSAs did not change over the period 1959–63.

exceed $10,000; the mean values of a fitted Pareto distribution were used for the higher income groups.

The corresponding data on hourly earnings are based on the 1/1,000 sample of the 1960 Census of Population. The sample includes information on annual income and earnings in 1959, number of weeks worked during that year, and number of hours worked during the survey week in 1960. To obtain a measure of annual hours we multiplied the number of weekly hours by the number of employment weeks for each person employed both in 1959 and in the survey week (persons employed in agriculture were excluded). Hourly earnings were estimated by dividing a person's annual earning by the estimate of his annual hours of work. This figure was averaged over all the persons in the same income group to yield an estimate of the average hourly earnings.[5] Biases introduced in this measure due to an inaccurate measure of annual working hours have only a slight effect on the estimate of hourly earnings for the upper income groups, who constitute the major part of air travelers.

Seventy-eight per cent of all business travelers in the sample belong to the professional, technical, official, or managerial occupations. Therefore, as a measure of a business traveler's hourly earnings we used the value of the average earnings of these occupations. Moreover, ninety-one per cent of all business air travelers in the sample are males. Hence, we used as an alternative measure the hourly earnings figures of males belonging to those occupations.

Similarly, we employed two measures for the hourly earnings of personal travelers. As the first measure we used average hourly earnings for all the employed persons in 1959. However, because of the difference in the sex composition in the data for employed persons and that for personal travelers we computed a second measure—a weighted average of male or female hourly earnings, using the percentage of males and females among personal travelers (45 and 55 per cent, respectively) as weights.[6]

[5] For a description of the 1/1,000 sample and an evaluation of the reliability of the hours data, see Victor R. Fuchs, *Differentials in Hourly Earnings by Region and City Size, 1959*, Occasional Paper 101, National Bureau of Economic Research, New York, 1967. Note, however, that our measure of hourly earnings differs from the aggregate measure used by Fuchs.

[6] The estimates of hourly earnings for all employed, for males, for females, for all professional occupations, and for males in professional occupations are contained in Table 6.

TABLE 6

Average Hourly Earnings Classified by Income Groups

(dollars per hour)

Annual Family Income (dollars)	All Employed	Male	Female	Professionals and Managers	
				All	Male
Under 3,000	1.62	1.71	1.52	1.46	1.48
3,000—4,999	2.07	2.15	1.90	2.44	1.99
5,000—5,999	2.43	2.53	2.16	2.59	2.50
6,000—6,999	2.60	2.77	2.16	2.83	2.69
7,000—9,999	2.85	3.12	2.27	3.28	3.35
10,000—14,999	3.39	3.82	2.58	4.13	4.41
15,000—24,999	4.87	5.65	2.97	6.17	6.73
25,000 and over	12.96	14.30	6.99	14.05	14.95
All employed	2.75	3.06	2.12	3.77	4.10

We were not able to secure information on the identity of the flights included in the sample. Thus we had to substitute some average figures based on the *Official Air Line Guide* for 1963, for the exact measures of the fare and the elapsed time of the trips. The elapsed time depends on the type of equipment used for the flight (i.e., piston, turboprop, or turbojet), and on the time needed to reach the airport. The money outlays are a function of equipment used (jet vs. nonjet), class of service (first class vs. coach), and expenditures on the way to the terminal. We computed two weighted averages of the fastest time and the most prevalent time of the different kinds of equipment, weighted by the share of each equipment in the daily schedule, but found that these measures are almost perfectly correlated with a simpler measure—the fastest scheduled flight on each route. Likewise, we computed a weighted average of first class and economy fares corrected for jet surcharges, to find that this variable is almost perfectly correlated with the economy (coach) fares (almost two-thirds of the passengers in the sample used this class of service). For the sake of simplicity we used, therefore, the estimate of the coach fare and fastest elapsed time, to which we added the Guide's estimates of the limousine fare and the average driving time from city center to the airport at both terminals.

The last variable required for the estimation of equation (5.7) is a measure of the "attractiveness" of the point of destination. This variable is a function of population size, level of economic activity, scenery, points of interest, etc. A common procedure calls for the quantification of these factors and their insertion in the estimation equation. Alternatively, one can use a somewhat more indirect approach. Since the qualities that make a place attractive for travelers also contribute to the demand for transportation-substitutes, one should be able to deduce the measure of attractiveness from the demand for the latter. Some of the trip's closest substitutes are found among other communication activities. For example, the daily volume of intercity telephone calls depends on telephone rates, the attractiveness of the two cities, and their population size; the latter variable playing a dual role as a scale factor and as one of the factors determining the city's attractiveness. We assume that these three variables are exhaustive,

$$\log N_j = A_0 + A_1 \log P_{Tj} + A_2 \log G'_j + A_3 G''_j, \tag{5.8}$$

where N_j denotes the average daily volume of long distance calls from New York to city j ($j = 1, 2, \ldots, 38$), P_{Tj} is the corresponding telephone rate, G'_j is the population size of SMSA j, and G''_j stands for the other factors determining the attractiveness of j. Put differently, the attractiveness measure G''_j can be derived as the residual in the logarithmic regression of the dependent variable N_j on the two measurable independent variables P_{Tj} and G'_j

$$G''_j = \frac{1}{A_3} (\log N_j - A_0 - A_1 \log P_{Tj} - A_2 \log G'_j). \tag{5.9}$$

Specifically,

$$G''_j = \frac{1}{A_3} [\log N_j - (8.7979 - \underset{(.2393)}{1.6016} \log P_{Tj} + \underset{(.0937)}{1.0059} \log G'_j)]$$
$$\text{adj } R^2 = .80, \tag{5.10}$$

where the figures in parentheses represent the corresponding standard errors of the regression coefficients.[7] Assuming arbitrarily that $A_3 = 1$, we

[7] The information on the daily volume and the telephone rates (measured in cents per 3 minutes) was obtained through the courtesy of the American Telephone and Telegraph Company, Long Lines Department, New York. The information on the SMSAs' population (measured in thousands) is based on the 1960 *Census of Population*, Table 33. An alternative measure, the volume of intercity mail, had to be rejected because of the nonexistence of such data.

used as the attractiveness measure (G_j in equation 5.7) two variables: population size (G'_j) and the residual (G''_j)

$$\log X_{ij} = \beta_0 + \beta_1 \log (P_j + kW_iT_j) + \beta_2 \log Y_i + \beta'_3 \log G'_j + \beta''_3 G''_j + u_{ij}. \quad (5.11)$$

Intercity telephone rates are linearly related to intercity distance. The definition of the attractiveness factor (G''_j) is based, therefore, on the tacit belief that the destination's distance does not affect its attractiveness. This is an assumption that is somewhat hard to defend in the case of business trips. More than one-third of all air passenger trips are for the purpose of visiting a customer, a branch, an agent, the home office, or the supplier.[8] In this case, the knowledge of the market and transportation and communication costs favor a place that is close at hand, and the attractiveness of a place is, therefore, inversely related to distance. The adverse effect distance has on the demand for trips may be explained in this case by its adverse effect on the attractiveness of the visit and by its direct effect on the trip's price. By ignoring the first of these two effects (assuming that the covariance between M_j and G''_j equals zero) one tends to overplay the role of the second; that is, one tends to overestimate the price effect.

The dependent variable describes the average number of trips to a given destination by travelers in a certain income group. Each such average is based on a different number of observations. To correct for heteroscedasticity due to a different number of observations in each cell, we employed a weighted regression.[9] The estimates of equation (5.11) are presented in Table 7.[10]

The explanatory power of the equation is very high both in the case of business and personal trips (the adjusted R^2 are .9 and .8, respectively). The major determinants of the demand for air travel are the traveler's skills and his place in the organizational hierarchy, as reflected by his income. Differences in income explain over one half of the dispersion of the number of trips among different individuals and among

[8] The Port of New York Authority, *op. cit.*, Table 10, p. 59.

[9] See S. J. Prais and H. S. Houthakker, *The Analysis of Family Budgets,* Cambridge, 1955, pp. 55–62.

[10] For a glossary of the terms used, see Table 8. We also tried to fit some other functional forms to the data: the linear, the semilogarithmic, and the semilogarithmic reciprocal. All these forms yielded results that were inferior to those of the simple logarithmic function.

TABLE 7

Partial Regression Coefficients of Business and Personal Trips

$$\log X = b_0 + b_1 \log (P + kWT) + b_2 \log Y + b_3 \log G' + b_4 G''$$

		Intercept		Price	
k	adj. R^2	b_0	t	b_1	t
BUSINESS TRIPS					
0	.87688	−16.63	−31.45	−.67	−15.46
A. W = Wage professionals					
.25	.88012	−17.29	−33.62	−.75	−15.98
.50	.88152	−17.82	−35.06	−.80	−16.21
.75	.88214	−18.24	−36.07	−.85	−16.32
1.00	.88238	−18.59	−36.81	−.88	−16.36
1.15[a]	.88242	−18.78	−37.15	−.90	−16.37
1.25[a]	.88242	−18.89	−37.35	−.91	−16.36
2.00	.88204	−19.57	−38.30	−.98	−16.30
B. W = Wage male professionals					
.25	.87959	−17.35	−33.68	−.75	−15.90
.50	.88039	−17.91	−35.10	−.80	−16.03
.65[a]	.88049	−18.19	−35.72	−.83	−16.04
.70[a]	.88049	−18.27	−35.89	−.84	−16.04
.75	.88047	−18.36	−36.06	−.85	−16.04
1.00	.88022	−18.73	−36.71	−.88	−16.00
2.00	.87840	−19.73	−37.91	−.98	−15.70
PERSONAL TRIPS					
0[a]	.81156	−11.23	−21.68	−.34	−7.42
A. W = Average wage					
.25	.80786	−11.52	−22.41	−.33	−6.84
.50	.80519	−11.72	−22.92	−.33	−6.41
.75	.80313	−11.87	−23.29	−.33	−6.06
1.00	.80149	−11.99	−23.58	−.32	−5.77
2.00	.79720	−12.29	−24.21	−.30	−4.96
B. W = Weighted average wage					
.25	.80936	−11.42	−22.18	−.34	−7.08
.50	.80764	−11.56	−22.55	−.34	−6.81
.75	.80623	−11.68	−22.85	−.35	−6.58
1.00	.80506	−11.77	−23.09	−.35	−6.38
2.00	.80175	−12.02	−23.69	−.35	−5.82

[a] R^2 at maximum.

Income		Population		Tastes	
b_2	t	b_3	t	b_4	t
1.80	40.49	76	19.40	.96	13.95
1.90	42.79	.77	19.85	.95	14.03
1.98	43.80	.78	20.11	.95	14.03
2.05	44.15	.78	20.27	.95	14.01
2.11	44.15	.78	20.38	.94	13.97
2.14	44.05	.79	20.43	.94	13.95
2.16	43.96	.79	20.46	.94	13.93
2.27	42.96	.80	20.60	.93	13.81
1.91	42.77	.77	19.82	.95	14.00
1.99	43.62	.78	20.02	.95	13.98
2.04	43.77	.78	20.09	.95	13.95
2.05	43.79	.78	20.11	.95	13.94
2.06	43.78	.78	20.13	.95	13.93
2.12	43.59	.78	20.19	.94	13.87
2.29	41.82	.80	20.27	.94	13.63
1.21	31.21	.52	12.26	1.31	23.21
1.24	31.58	.52	12.24	1.30	22.90
1.26	31.50	.53	12.21	1.30	22.67
1.28	31.22	.53	12.19	1.29	22.50
1.29	30.84	.53	12.18	1.29	22.36
1.32	29.06	.53	12.12	1.28	22.00
1.23	31.57	.52	12.27	1.31	23.04
1.25	31.67	.53	12.28	1.31	22.91
1.26	31.62	.53	12.28	1.30	22.80
1.28	31.48	.53	12.28	1.30	22.70
1.31	30.56	.53	12.27	1.30	22.43

TABLE 8

Glossary of Symbols and Notations

Notation	Name	Explanation	Unit
X_{ij}	Trips per family	Number of trips to destination j per family in income group i	Trips per thousand families per year
G'_j	Population	The population size of the SMSA of destination j	Thousands
G''_j	Tastes	The residual of the logarithmic regression of number of telephone calls on telephone rates and population	
Y_i	Income	Average income for income group i	Dollars per annum
P_j	Fare	Airline average economy fare from New York to destination j	Dollars
T_j	Elapsed time	Elapsed traveling time (based on the fastest flying time to destination j)	Hours
K_i	Price of time	The value the traveler places on his time	Dollars per hour
Π_{ij}	Price of the trip	$= P_j + K_i T_j$	Dollars
W_i	Hourly earnings	Average of hourly earning of managers and professionals (or male managers and professionals)	Dollars per hour
k	The ratio of the price of time to hourly earnings	$= K_i/W_i$	

different places, price playing only a minor role in the explanation of traffic patterns. The absolute value of the income and price elasticities was found to be higher in the case of business trips than in the case of personal trips. In both cases the income elasticities (2.0 and 1.2) are significantly greater than unity, and the price elasticities (−.8 and −.3) are smaller than one. (In the case of business trips this result is not statistically significant at a level of significance of $\alpha = .01$.)

The effect income has on personal trips differs conceptually from the effect it has on business trips. For personal trips income measures the passenger's ability to pay for the trip, while for business trips it is a proxy for the passenger's skills and, hence, the difference between his marginal product at the point of origin and at the point of destination. A comparison of the income elasticities is, therefore, meaningless.

The finding that business travelers are more sensitive than personal travelers to changes in the trip's price may at first seem somewhat surprising. This difference may be explained by differences in the frequency and the duration of the trip, and by biases resulting from an inaccurate measurement of the attractiveness factor. The average frequency of air trips of a business traveler is more than twice as large as that of a personal traveler (8 trips vs. 3 trips per year, respectively).[11] The rate of return and the investment in information are, therefore, going to be greater in the case of business trips than in the case of personal trips. This increased investment in information increases the business traveler's sensitivity to change in price. Alternatively, this difference may be explained by the smaller share of the trip's price in the cost of the visit. The costs of the visit vary directly with its duration. The duration of a business visit is significantly shorter than the duration of a personal trip. Business trips constitute over 75 per cent of all visits with a duration of three nights or less, but accounted for less than 40 per cent of the trips that lasted eight nights or more.[12] A percentage increase in the trip's price increases the costs of a personal visit less than the costs of a business visit, and results in an increased price elasticity for business trips. Finally, it was shown that the estimates of the price elasticity of business trips may suffer from an upward bias originating in the assumption that the attractiveness measure (G''_j) and distance are uncorrelated.[13]

We were unable to derive an estimate of the value placed on time by personal travelers. On the other hand, for business travelers we estimated that the price of time almost equals hourly earnings. In investigating the demand for personal trips, equation (5.11) assumes its highest explanatory power when the price of time is assumed to equal zero. On the other hand, in the case of business trips, R^2 is at its maximum when $1.15 < k < 1.25$ when the price of time is related to the hourly earning of professionals and managers, and at $.65 < k < .70$ when the price of time is related to the wage of male professionals and managers. Both of

[11] The Port of New York Authority, *op. cit.*, p. 24.

[12] *Ibid.*, p. 17.

[13] See p. 46 above.

these values do not differ significantly from the explanatory value of the equation when $k = 1.0$, i.e., both estimates are consistent with the hypothesis that the price of time equals hourly earnings. On the other hand, both equations yield a significantly higher explanatory value than the assumption $k = 0$, i.e., the assumption that the price of time is unrelated to income. The omission of the cost of time effect results, as Table 7 clearly indicates, in an underestimate of both the price and the income elasticities.[14] Note, however, that k is a random variable and subject to a random distribution, and may also admit, therefore, some different interpretations.

The results concerning personal trips prove again to be puzzling. The finding that the price of time is unrelated to hourly earnings can be explained only in terms of the low degree of substitution of time between work and nonwork activities. Of all personal trips, over one half were taken during a weekend or a holiday, and almost one half were taken by travelers who were unemployed (the corresponding figures for business trips were 39 and 4 per cent respectively).[15] The

[14] Compare the estimated parameters of business trips when $k = 0$ and when $k = 1.25$ These results support the theoretical expectations: let the true relationship be

$$y = \beta_1 x_1 + \beta_2 z + u;$$

a misspecification results in an estimate,

$$y = b_1 x_1 + b_2 x_2 + e;$$

then

$$Eb_1 = \beta_1 + \beta_2 \gamma_{zx_1 \cdot x_2},$$

and

$$Eb_2 = \beta_2 \gamma_{zx_2 \cdot x_1},$$

where $\gamma_{zx_1 \cdot x_2}$ denotes the partial regression coefficient of z on x_1 holding x_2 constant.

In our specific case

$$z = \log (P + kWT),$$
$$x_1 = \log Y,$$

and

$$x_2 = \log P.$$

Hence, $\gamma_{zx_1 \cdot x_2} > 0$, $\gamma_{zx_2 \cdot x_1} < 1$, and $\beta_2 < 0$. Consequently,

$$E(b_1) < \beta_1, |E(b_2)| < |\beta_2|.$$

[15] The Port of New York Authority, *op. cit.*, pp. 18, 50, 76.

foregone earnings involved in these personal trips are substantially lower than those involved in business trips taken on a regular weekday. Still, these differences may not explain the complete lack of responsiveness to the amount of elapsed time. The estimation of the price of time of personal travelers calls for additional investigation.

To test our assumption that the price of time is not affected by distance we reestimated the demand for business trips, limiting our observations to routes whose distance exceeds 175 miles. An estimate of equation (5.11) based on 35 city pairs is reported in Table 9. The experiment was repeated for business trips to the 23 cities whose distance from New York exceeds 500 miles.

Equation (5.11) attains its maximum explanatory power in the first case when $.95 < k < 1.05$ and in the second case when $1.15 < k < 1.20$ (see Table 9). The price elasticity in both cases is somewhat (though not significantly) smaller than unity ($.9 < \hat{\beta}_1 < 1.0$) and the income elasticity is significantly greater than one ($\hat{\beta}_2 = 2.1$). The comparison of these results with the results of Table 7 does not indicate any systematic relationship between the price of time and distance.

Past studies have argued that the New York demand for air trips differs from that of other cities.[16] The Port of New York Authority data does not allow for a direct test of this hypothesis. An indirect test of the hypothesis is based on the comparison of the demand of New York residents leaving the city and the demand of residents of other places going home. The estimates of (5.11) for resident business travelers are reported in Table 10.

The estimates tend to confirm our previous findings that the price elasticity of business trips is close to unity, the income elasticity is close to two, and the price of time of business travelers equals their hourly earnings. We could not find any evidence substantiating the claim that these results are peculiar to New York City.

How do these estimates compare with existing estimates of the price and income elasticities and with some implicit estimates of k? There are hardly two studies in this field that agree on the values of the income and price elasticities. The argument whether the price elasticity, a crucial variable for any pricing policy, is less or greater than unity goes back

[16] J. B. Lansing, Jung Chao Liu, and D. B. Suits, "An Analysis of Interurban Air Travel," *Quarterly Journal of Economics,* February 1961.

TABLE 9

Partial Regression Coefficients of Business Trips by Distance

$[\log X = b_0 + b_1 \log (P + kWT) + b_2 \log Y + b_3 \log G' + b_4 G'']$

		Intercept		Price	
k	adj. R^2	b_0	t	b_1	t
175 + MILES					
A. W = Wage professionals					
.25	.89243	−16.94	−33.41	−.81	−17.47
.50	.89370	−17.49	−34.99	−.87	−17.69
.75	.89417	−17.95	−36.11	−.92	−17.77
.95[a]	.89427	−18.26	−36.77	−.95	−17.79
1.00[a]	.89427	−18.33	−36.91	−.96	−17.79
1.05[a]	.89427	−18.39	−37.05	−.96	−17.79
2.00	.89348	−19.37	−38.59	−1.06	−17.65
B. W = Wage male professionals					
.25	.89184	−17.00	−33.47	−.82	−17.37
.50	.89247	−17.59	−35.02	−.87	−17.47
.55[a]	.89248	−17.70	−35.26	−.88	−17.48
.60[a]	.89248	−17.80	−35.49	−.89	−17.48
.75	.89236	−18.07	−36.07	−.92	−17.45
1.00	.89194	−18.47	−36.80	−.95	−17.38
2.00	.88957	−19.55	−38.14	−1.06	−16.98
500 + MILES					
A. W = Wage professionals					
.25	.88843	−17.17	−26.47	−.75	−8.42
.50	.88946	−17.55	−27.98	−.80	−8.59
.75	.88998	−17.89	−29.20	−.83	−8.67
1.00	.89019	−18.19	−30.18	−.86	−8.70
1.15[a]	.89023	−18.35	−30.67	−.87	−8.71
1.20[a]	.89023	−18.40	−30.82	−.88	−8.71
2.00	.88981	−19.07	−32.46	−.93	−8.64
B. W = Wage male professionals					
.25	.88805	−17.22	−26.58	−.75	−8.37
.50	.88872	−17.64	−28.15	−.79	−8.47
.70[a]	.88885	−17.93	−29.16	−.82	−8.49
.75[a]	.88885	−18.00	−29.38	−.83	−8.49
1.00	.88872	−18.32	−30.35	−.85	−8.47
2.00	.88725	−19.24	−32.44	−.91	−8.24

[a] R^2 at maximum.

Income		Population		Tastes	
b_2	t	b_3	t	b_4	t
1.91	43.93	.75	19.64	.89	13.29
2.00	45.03	.75	19.92	.88	13.30
2.07	45.42	.76	20.09	.88	13.27
2.12	45.45	.76	20.19	.88	13.24
2.13	45.44	.76	20.21	.88	13.23
2.14	45.41	.77	20.23	.88	13.22
2.31	44.21	.78	20.44	.87	13.05
1.92	43.90	.75	19.60	.89	13.26
2.01	44.82	.76	19.82	.88	13.24
2.02	44.90	.76	19.85	.88	13.23
2.04	44.95	.76	19.87	.88	13.22
2.08	45.00	.76	19.94	.88	13.18
2.15	44.80	.77	20.00	.88	13.12
2.33	42.93	.78	20.08	.87	12.86
1.90	35.22	.76	20.07	.72	8.77
1.96	35.42	.77	20.28	.71	8.73
2.02	35.11	.77	20.43	.71	8.68
2.07	34.56	.78	20.52	.70	8.64
2.09	34.17	.78	20.57	.70	8.61
2.10	34.04	.78	20.58	.70	8.60
2.21	21.90	.79	20.69	.70	8.48
1.91	35.18	.76	20.04	.72	8.76
1.97	35.22	.77	20.22	.71	8.70
2.02	34.86	.77	20.31	.71	8.65
2.03	34.73	.77	20.33	.71	8.64
2.08	34.00	.78	20.39	.71	8.59
2.22	30.84	.79	20.43	.70	8.40

TABLE 10

Partial Regression Coefficients of Business Trips by New York Residents

[$\log X = b_0 + b_1 \log (P + kWT) + b_2 \log Y + b_3 \log G' + b_4 G''$]

		Intercept		Price	
k	adj. R^2	b_0	t	b_1	t
0	.83409	−18.07	−28.95	−.64	−12.78
A. W = Wage professionals					
.25	.83732	−18.69	−30.68	−.72	−13.19
.50	.83869	−19.19	−31.84	−.77	−13.37
.75	.83925	−19.60	−32.66	−.81	−13.44
1.00[a]	.83940	−19.94	−33.25	−.85	−13.46
1.10[a]	.83940	−20.06	−33.43	−.86	−13.46
2.00	.83855	−20.88	−34.42	−.94	−13.35
B. W = Wage male professionals					
.25	.83690	−18.74	−30.74	−.72	−13.14
.50	.83778	−19.27	−31.91	−.77	−13.25
.65[a]	.83789	−19.54	−32.42	−.80	−13.26
.70[a]	.83789	−19.62	−32.56	−.81	−13.26
.75	.83787	−19.70	−32.70	−.82	−13.26
1.00	.83762	−20.06	−33.25	−.85	−13.23
2.00	.83552	−21.03	−34.24	−.94	−12.96

[a] R^2 at maximum.

into the fifties and has not yet been resolved.[17] The same dispersion is found in estimates of the income elasticity. The results prove to be very sensitive to the source of data used (time series vs. cross-sections), the independent variables included in the equation, and the equation's functional form. Any comparison made among the various estimates becomes, under these circumstances, meaningless.

Alternatively, one could evaluate the reliability of the different estimates by comparing their performance as predictors. However, most of the studies in the field are of quite recent origin and use up-to-date data. Their predictive power is not yet known and will not be for many years to come.

[17] For a summary of some of the arguments, see R. Caves, *Air Transport and Its Regulators,* Cambridge, Massachusetts, 1962, Ch. 2, pp. 34–54.

Income		Population		Tastes	
b_2	t	b_3	t	b_4	t
1.77	33.71	.91	20.36	.86	12.77
1.86	35.40	.92	20.72	.85	12.79
1.94	36.13	.92	20.92	.84	12.76
2.01	36.37	.93	21.05	.84	12.70
2.06	36.34	.93	21.13	.83	12.63
2.08	36.28	.93	21.16	.83	12.60
2.22	35.29	.94	21.30	.82	12.33
1.87	35.41	.92	20.69	.85	12.77
1.95	36.06	.92	20.87	.84	12.72
1.99	36.17	.93	20.93	.84	12.67
2.01	36.18	.93	20.95	.84	12.65
2.02	36.17	.93	20.96	.84	12.64
2.08	36.02	.93	21.02	.83	12.55
2.24	34.59	.95	21.10	.82	12.21

There are at least four published studies that attempt to estimate the trade-off between time and money in transportation. One of these studies, Blackburn's study of traveling patterns in California,[18] employs a functional form that does not allow an easy comparison of his results with ours. Becker estimated the value of time from the relation between the value of land and the commuting distance from home to place of employment. An estimate based on the experience of commuters in Seattle rendered a value of time which was about 40 per cent of the commuter's average hourly earning.[19] The third study is based on the

[18] A. J. Blackburn, "A Nonlinear Model of Passenger Demand," in *Studies in Travel Demand,* Vol. II, prepared by Mathematica for the Department of Transportation, Princeton, New Jersey, 1966.

[19] Gary S. Becker, "A Theory of the Allocation of Time," *Economic Journal,* September 1965, p. 510.

commuter's experience in London. Beesley tried to estimate what is essentially the switching distance between the various modes of public transportation. Given these estimates, he then estimated the price of time of two different income groups, observing a value of time which was 30–35 per cent of the hourly wage.[20] The difference between these estimates and our estimate of the business traveler's price of time can be attributed to the peculiar nature of commutation trips. Commutation can be regarded as "productive consumption." It is a consumption activity that serves as an input in the production of the activity "work." As shown in Chapter 2, the value of time in such activity equals the wage rate only if the traveler is free to substitute working time for traveling time and if work does not yield any disutility. If either of these two assumptions is violated we may expect the price of time to be lower than the wage rate.

The fourth and most recent of these studies is the forecast by the Institute for Defense Analyses of the future demand for trips by supersonic passenger planes. This study concludes "that passengers in the aggregate act as though they value their time at approximately their earning rate," and that there is no evidence that personal travelers differ in that respect from business travelers.[21] We cannot agree with the second finding, but the IDA's aggregate estimates fully support our findings with respect to the price of time of business travelers.

[20] M. E. Beesley, "The Value of Time Spent in Traveling: Some New Evidence," *Economica,* May 1965.

[21] Institute for Defense Analyses, *Demand Analysis of Air Travel by Supersonic Transport,* Washington, D.C., December 1966, Vol. I, pp. xv, 16–19; Vol. II, Appendix C, pp. 31–59.