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ON FEBRUARY 17th, 1972 the Metropolitan Atlanta Rapid Transit Authority (MARTA), a public agency created in 1965, purchased the privately-owned Atlanta Transit System, Inc. MARTA immediately took over operation of the company's bus lines, and commenced the implementation of a "short-range transit improvement program" assisted by a $33 million capital grant from the Urban Mass Transportation Administration. Details of this program have been described by Kiepper et al. (1973).

MARTA's policy for the operation of both the bus lines and the new fixed rail rapid transit system currently under design in the city is to maintain "low fares"—that is to say, fares well below both the market level and the level necessary to recover operating costs fully. Deficits on operating account (as well as the city's contribution to the construction costs of the new system) are to be recouped from the revenues of a special one percent sales and use tax imposed over the participating local jurisdictions.

Consequently, on March 1st, 1972 the basic bus fare was reduced from 40¢ to 15¢ per ride. In addition, during the first year of the transit system's operation under public ownership various other aspects of the short-range transit improvement program were implemented. Of these the most significant are several increases in service provision, equivalent in total (by February 1973) to an increase of roughly 30 percent in the annual vehicle miles operated.

This paper documents a very simple empirical exercise in which MARTA's monthly operating statistics for the period from January 1970 through February 1973 were examined to investigate what might be deduced about the demand response to the fare and service changes. Despite the fact that the time span considered is a short one and that the limited data available are of a very aggregate nature, it has proved possible to account successfully for the month-to-month ridership variations on the system, and hence to identify the effects of MARTA's innovations.

Atlanta's transit system, 1970 to 1973

In calendar year 1970 Atlanta Transit System, Inc. operated a total of 19.43 million vehicle miles over roughly 80 bus routes. Approximately 48.1 million passengers paid a base fare of 35¢, and of these about 12.6 million paid an extra 5¢ in order to transfer between lines. The population of the area served by the system was approximately 780,000.

The base fare was increased on March 5th, 1971 to 40¢, still retaining the 5¢ transfer charge. On March 1st, 1972, after MARTA had assumed operation of the system, the fare was reduced to a flat 15¢, all zonal surcharges were abolished, and so was the transfer charge. This reduction, however, did not apply throughout the entire system. Clayton County had not approved the one percent sales tax levy, and fares for services within that county remained at the previous level. Fares for special services (the Stadium Shuttle, the Falcon Flyer, Six Flags services, for example) were not reduced, nor was the 10¢ school fare. Overall, MARTA estimates that at the time of the fare cut roughly 83 percent of the revenue passenger trips were affected by the reduction.

In addition, over the first year of public operation of the system (March 1972 through February 1973) a total of 5.80 million annual vehicle miles were added, an increase of roughly 30 percent.

THE ADOPTED MODEL OF TRANSIT RIDERSHIP

The analysis described here is posited on the hypothesis that longitudinal variations in aggregate transit ridership in a metropolitan area can be accounted for adequately by a relatively small number of explanatory variables. Previous work by the statistical laboratory of the Massachusetts Institute of Technology (Rainville, 1948) and by Carstens & Csanyi (1968), both using annual rather than monthly operating statistics, support this hypothesis.

The model further assumes that the observed time series of rider volumes can be decomposed into three component series which are additive:

$$y_t = d_t + s_t + \epsilon_t \quad (t = 1 \ldots\ldots N)$$

where y_t is the t^{th} observation of the time series,

d_t is a non-seasonal deterministic component

s_t is a seasonal component

and ϵ_t is a random error component.

If d_t and s_t are themselves linear functions of other parameters, then a model of this nature satisfies the hypothesis of the general linear statistical model and may be estimated by standard methods of linear regression.

From the longitudinal data available, it was decided to select the revenue passenger volumes for use as the principal endogenous variable in this analysis. The revenue passenger volumes for

The Effects of Atlanta's Short-Range Transit Improvement Program on System Ridership

*by Michael A. Kemp**

each month from March 1970 through February 1973 are graphed in Figure 1.

PATRONAGE OF ATLANTA'S TRANSIT SYSTEM: ACTUAL PASSENGER VOLUMES

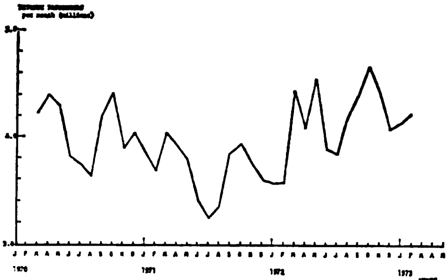

FIGURE 1

Examining first the period prior to March 1972, the graph exhibits some fairly strong seasonal variations with, as one might expect a priori, a periodicity of one year. Ridership is lowest in the summer months of June, July, and August (probably due in some measure to school vacations in these months), and peaks in March and October. Underlying the monthly variations there appears to be, as with the majority of U.S. transit systems, a downward trend.

Ridership rose sharply in March 1972 following the MARTA fare cut, but the seasonal variation during the subsequent year broadly followed the pattern of the preceding years with a summer trough and an October peak.

The variables used in the analysis

The model adopted here hypothesizes that the month-to-month variations observed in revenue passenger volumes are, in part, determined by:

- the money price (to the passenger) of the service. A priori we would expect that the higher the transit fare, the lower will be the ridership—since as the price rises, consumers at the margin will divert to other modes or cease to travel.
- the level of service provided by the system. The available empirical evidence (a review of which appears in Kemp, 1973) strongly suggests that transit ridership is relatively more sensitive to changes in the level of service supplied—in particular, to door-to-door journey times—than it is to changes in money price.
- the number of days in the month. Part of the monthly variation in ridership may be expected to reflect differences in the lengths of months, and in particular, variations in the number of working days in the month. MARTA estimates that Saturday and Sunday ridership averages roughly 43 percent and 15 percent respectively of a weekday's ridership.

In addition to these three deterministic variables, the model quantitatively incorporates two other components:

- a secular trend variable, representing the effects of those non-seasonal influencing factors not considered explicitly
- a pattern of seasonal variations, with annual periodicity, representing the effects of those seasonal influencing factors not explicitly considered.

Table 1 defines the set of basic variables entering into the analysis. The only available measure of the level of service provided by the system was the total vehicle miles operated during the month (TVM). Since the transit passenger or potential passenger predominantly evaluates service in terms of such factors as door-to-door journey times, access (walking and waiting) times, number of transfers, and reliability, TVM must be regarded as a very inadequate measure for this purpose.

The money price variable, FARE, is the basic bus fare for the system, which is not the same as the average fare paid per revenue passenger. An average fare value would be a more appro-

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BASIC VARIABLES USED IN THE ANALYSIS

Variable name	Description
T	**time variable** Months are numbered consecutively, commencing with January 1970 as unity.
NWD	**number of non-working days** Total number of Saturdays, Sundays, and public holidays occurring in the month.
WD	**number of working days** This is the difference between the total number of days in the month and the number of non-working days in the month.
FARE	**system basic bus fare** The basic fare (in cents) in operation during the month, using a weighted mean for those months in which fare charges occurred.
RP	**revenue passengers** Total number of revenue passengers (that is, counting transferring passengers once only) carried during the month, in thousands.
TVM	**total vehicle miles** Total bus miles operated over the whole system during the month, in thousands.
D_i ($i=1,2\ldots12$)	**dummy variable for each month** $D_i=1$ for the ith month of the year $D_i=0$ for all other months in the year

TABLE 1

priate measure, but for technical reasons it is difficult to form an accurate estimate of this from the available data.

Seasonal effects are accounted for in the model by introducing a set of twelve dummy variables (D_i), one for each month of the year—this is one standard technique of seasonal adjustment in time series analysis (Jorgenson, 1964). Since twelve-month moving averages of the revenue passenger volumes correlated slightly (but not significantly) more closely with the logarithmic transform of the trend variable T, $\log_e T$ was employed in preference to T throughout all model estimations.

Other variables, formed from the basic set, were used in some model estimations. Revenue passengers per working day (RP/WD) was computed by dividing the total revenue passengers in each month (RP) by the total number of working days in the month (WD); total vehicle miles per working day (TVM/WD) was calculated similarly. On the hypothesis that the demand reaction to service improvements may be a slow one because of imperfections in information dissemination, a lagged value of the service supply variable was also tested; this variable represents the total vehicle miles operated during the preceding month.

Estimation of the model

Using ordinary least squares estimation, a number of models were calibrated[1] in which ridership (either RP or RP/WD) was expressed as a linear function of various sets of the explanatory variables. Fourteen of these models are summarized in Tables 2, 3, and 4. They are categorized into four different groups:

- Group A models use RP as the endogenous variable, and are based on the data for March 1970 through February 1972, just prior to the MARTA fare decrease;
- Group B models use RP/WD as the dependent variable, based on the March 1970 to February 1972 data;
- Group C models use RP as the dependent variable, and are based on data for March 1970 through February 1973, thus implicitly incorporating the effects of MARTA's short-range improvement program;
- Group D models use RP/WD as dependent variable, based on the March 1970 to February 1973 data.

Tables 2, 3 and 4 present the estimated coefficients for the variables in each of the models, together with the values of Student's t statistic associated with each coefficient. Summary statistics for the goodness-of-fit for the model as a whole are also presented.

It is readily apparent from inspection of these tables that all fourteen of the model formulations summarized there give a good explanation of the month-to-month variations in revenue passenger volumes over the time period on which they are based. All but one of the formulations calibrated on pre-March 1972 data (groups A and B) account for over 90 percent of the total longitudinal variance in ridership; all of the models based on 1970 through 1973 data (groups C and D) explain at least 86 percent of the variance. The coefficient of multiple determination and the variance ratio for every one of the fourteen are highly significant at the 0.1 percent level.

Moreover, the signs and magnitudes of the estimated coefficients are predom-

LINEAR REGRESSION MODELS OF RIDERSHIP VOLUMES—GROUP A

Dependent Variable: RP | Period: March 1970 through February 1972

Equation #	TVM	FARE	WD	NWD	logT	D_1	D_2	D_3	D_4	D_5	D_6	D_7	D_8	D_9	D_{10}	D_{11}	D_{12}	F	DW	R^2
A1					-332.0	4659	4602	4762	4846	4769	4380	4298	4323	4893	5064	4747	4750	15.35	2.08	0.832
					-7.59*	31.52*	30.69*	42.12*	40.78*	38.56*	34.27*	32.69*	32.07*	35.51*	36.02*	33.16*	32.63*			
A2			0.827	-108.0	-347.6	5929	5658	5691	5833	5974	5372	5290	5371	5889	6332	5799	5747	20.06	1.36	0.921
			0.006	-0.713	-9.48*	1.38	1.44	1.34	1.41	1.39	1.30	1.24	1.26	1.43	1.47	1.40	1.35			
A3	2.005				-288.8	1369	1413	1329	1444	1335	1161	1079	1108	1562	1573	1484	1418	19.51	1.17	0.913
	2.20				-6.80*	0.91	0.97	0.85	0.93	0.85	0.79	0.74	0.76	1.03	0.99	1.00	0.93			
A4		-46.71			-115.0	5782	5713	6085	6146	6038	5624	5519	5524	6076	6231	5898	5887	17.52	2.44	0.903
		- 1.84			-0.925	9.26*	9.24*	8.39*	8.61*	8.65*	8.22*	8.20*	8.33*	9.29*	9.65*	9.25*	9.33*			
A5	2.598	-60.04				1850	1908	2022	2116	1959	1814	1704	1709	2105	2048	2007	1903	66.54	2.40	0.97[illegible]
	5.48*	-13.30*				2.24*	2.38*	2.33*	2.46*	2.26*	2.23*	2.09	2.10	2.51*	2.34*	2.44*	2.28*			

NOTES:

- The number appearing beneath each coefficient represents the value of Student's t statistic for that coefficient. An asterisk identifies those values which are significant at the 5% significance level.
- F is the variance ratio for the model as a whole. All of the values cited are highly significant at the 0.1% level.
- DW is the value of the Durbin-Watson Statistic.
- R^2 is the coefficient of determination for the model as a whole, corrected for the number of degrees of freedom. It represents the proportion of the total variance in the dependent variable which is explained by the model. All of the values cited are highly significant at the 0.1% level.

TABLE 2

LINEAR REGRESSION MODELS OF RIDERSHIP VOLUMES—GROUP B

Dependent Variable: RP/WD

Period: March 1970 through February 1972

Equation #	Coefficients: TVM	FARE	logT	D_1	D_2	D_3	D_4	D_5	D_6	D_7	D_8	D_9	D_{10}	D_{11}	D_{12}	F	DW	R^2
B1			-17.25	239.9	246.9	216.6	233.8	239.9	212.0	200.5	205.9	236.8	260.2	234.7	222.0	29.94	1.07	0.938
			-9.13*	37.57*	38.13*	44.36*	45.54*	44.92*	38.40*	35.30*	35.37*	39.79*	42.85*	37.96*	35.31*			
B2	-0.060		-18.54	337.9	342.0	318.9	335.2	342.2	308.0	296.4	301.8	336.1	364.3	332.0	321.3	29.90	1.43	0.942
	-1.56		-9.03*	4.66*	4.87*	4.22*	4.48*	4.53*	4.35*	4.18*	4.26*	4.58*	4.74*	4.62*	4.38*			
B3		-2.926	-3.656	310.3	316.6	299.5	315.2	319.4	289.9	277.0	281.1	310.9	333.2	306.8	293.2	54.74	1.93	0.968
		-3.38*	-0.862	14.56*	15.00*	12.09*	12.94*	13.41*	12.40*	12.05*	12.42*	13.93*	15.12*	14.09*	13.61*			
B4	-0.031	-2.695	-5.408	356.3	361.1	346.8	362.2	367.0	334.2	321.4	325.6	357.3	382.2	352.3	339.9	50.07	2.01	0.968
	-0.916	-2.97*	-1.15	6.52*	6.81*	6.05*	6.37*	6.41*	6.21*	5.98*	6.07*	6.45*	6.60*	6.49*	6.14*			

NOTES:

- The number appearing beneath each coefficient represents the value of Student's t statistic for that coefficient. An asterisk identifies those values which are significant at the 5% significance level.
- F is the variance ratio for the model as a whole. All of the values cited are highly significant at the 0.1% level.
- DW is the value of the Durbin-Watson Statistic.
- R^2 is the coefficient of determination for the model as a whole, corrected for the number of degrees of freedom. It represents the proportion of the total variance in the dependent variable which is explained by the model. All of the values cited are highly significant at the 0.1% level.

TABLE 3

LINEAR REGRESSION MODELS OF RIDERSHIP VOLUMES—GROUPS C AND D

Dependent Variable: RP (Group C); RP/WD (Group D)

Period: March 1970 through February 1973

Equation #	Coefficients																F	DW	R^2
	TVM	TVM/WD	FARE	LogT	D_1	D_2	D_3	D_4	D_5	D_6	D_7	D_8	D_9	D_{10}	D_{11}	D_{12}			
C1			-27.46	-219.4	5357	5347	5567	5500	5599	5113	5037	5173	5614	5811	5516	5400	18.26	2.61	0.865
			-11.04*	-5.05*	26.22*	25.94*	31.76*	30.48*	30.37*	27.23*	26.41*	26.74*	28.65*	29.31*	27.52*	26.68*			
C2	0.754		-21.87	-208.3	3867	3894	4110	4088	4131	3727	3655	3762	4167	4282	4066	3944	22.86	2.25	0.897
	2.82*		-7.44*	-5.47*	6.92*	7.13*	7.62*	7.78*	7.57*	7.18*	7.05*	7.12*	7.70*	7.52*	7.48*	7.22*			
D1			-1.377	-11.71	273.7	283.5	255.4	274.0	275.1	246.2	243.3	243.8	276.6	296.3	271.6	260.9	35.12	2.06	0.977
			-13.10*	-6.38*	31.72*	32.57*	34.51*	35.96*	35.34*	31.05*	30.21*	29.84*	33.42*	35.39*	32.10*	30.51*			
D2	0.002		-1.361	-11.68	269.4	279.3	251.2	269.9	270.9	242.2	239.4	239.8	272.4	292.0	267.5	256.7	31.17	2.09	0.923
	0.162		-9.34*	-6.19*	9.74*	10.32*	9.40*	10.37*	10.02*	9.42*	9.33*	9.16*	10.16*	10.34*	9.93*	9.49*			
D3		0.759	-1.108	-11.12	197.9	204.1	189.9	204.1	203.5	180.4	177.6	178.6	206.0	218.6	201.0	191.5	44.22	1.67	0.945
		3.53*	-8.81*	-6.85*	8.46*	8.67*	9.39*	9.52*	9.26*	8.82*	8.66*	8.76*	9.41*	9.17*	9.15*	8.85*			

NOTES:

- The number appearing beneath each coefficient represents the value of Student's t statistic for that coefficient. An asterisk identifies those values which are significant at the 5% significance level.
- F is the variance ratio for the model as a whole. All of the values cited are highly significant at the 0.1% level.
- DW is the value of the Durbin-Watson Statistic.
- R^2 is the coefficient of determination for the model as a whole, corrected for the number of degrees of freedom. It represents the proportion of the total variance in the dependent variable which is explained by the model. All of the values cited are highly significant at the 0.1% level.

TABLE 4

inantly in line with a priori expectations, with a very small number of exceptions. For example, all coefficients of the variable FARE are negative, as are all of the coefficients of the trend variable $\log_e T$; the coefficients of the supply variables TVM and TVM/WD are predominantly positive. The t statistic values show that many of the coefficients are significantly different from zero (at the 5 percent level), and in no case does a significant coefficient possess an anomalous sign.

RIDERSHIP AND THE FARE LEVEL

It is possible to use the estimated models of system ridership to isolate out the effects of fare changes alone on the volumes of revenue passengers. We shall discuss first the derivation of a fare elasticity of demand for the major price reduction of March 1, 1972.

Each of the fourteen equations summarized in Tables 2 through 4 may be used to predict the volumes of traffic which could have been expected during each month from March 1972 through February 1973, had the base fare remained at 40¢. This is done by extrapolating the models using the actual values for all exogenous variables except FARE (which is set equal to 40) when it appears explicitly in the equation. The predicted monthly revenue passenger volumes are then summed to provide total ridership estimates (at the 40¢ base fare) for three months, six months, and twelve months following the fare change. These totals can be compared with the actual traffic volumes observed over the same time periods, and the implied fare elasticities (designated η_3, η_6, and η_{12} respectively) may be computed.

The results of this procedure are summarized in Table 5. The elasticity estimates quoted there are arc-type values, computed from the formula

$$\eta = \frac{\Delta \log q}{\Delta \log p}$$

where q is the total revenue passenger volume over the time period

and p is the value of FARE.

There are several features of interest in Table 5. First, with the exception of three of the model formulations (A3, A5, and B2), the traffic volumes predicted at a 40¢ fare by the remainder of the equations are highly clustered, all estimates lying within six percent of the mean. The implied fare elasticities are consequently also very uniform. Secondly, the majority of the models show a numerically larger fare elasticity over six months than over three—but the twelve month elasticity values are typically very close to the six month values.

FARE ELASTICITIES FOR THE MARCH 1972 FARE REDUCTION

	Revenue passenger volumes			Implied fare elasticity		
	3 months, Mar '72 to May '72	6 months, Mar '72 to Aug '72	12 months, Mar '72 to Feb '73	η_3	η_6	η_{12}
	thousands	thousands	thousands			
Actual riders at 15¢ fare	13,033	24,996	50,948			
Predicted riders at 40¢ fare, from model:						
A1	11,098	20,640	42,246	-0.17	-0.20	-0.19
A2	11,053	20,643	42,068	-0.17	-0.20	-0.20
A3	11,172	21,474	46,544	-0.16	-0.15	-0.09
A4	11,515	21,393	43,309	-0.13	-0.16	-0.17
A5	11,782	22,660	49,147	-0.10	-0.10	-0.06
B1	11,022	20,579	41,990	-0.17	-0.20	-0.20
B2	10,929	20,011	39,364	-0.18	-0.23	-0.26
B3	11,634	21,592	43,391	-0.12	-0.15	-0.16
B4	11,352	21,797	42,856	-0.12	-0.14	-0.18
C1	11,178	20,946	42,703	-0.16	-0.18	-0.18
C2	11,362	21,469	44,412	-0.14	-0.16	-0.14
D1	11,110	20,806	42,423	-0.16	-0.19	-0.19
D2	11,122	20,839	42,323	-0.16	-0.19	-0.18
D3	11,279	21,302	44,000*	-0.15	-0.16	-0.15
Median value from the models	11,175	21,124	42,780	-0.16	-0.17	-0.18
MARTA estimates	11,255	20,811	41,352	-0.15	-0.19	-0.21

TABLE 5

The 5¢ fare increase of March 1971 may be examined in a similar way, although in this case not all of the fourteen models can be used to derive elasticity estimates—the Group A and B equations which do not explicitly incorporate the FARE variable are not appropriate for the purpose. The results are summarized in Table 6.

The models calibrated on the data through February 1972 (Groups A and B) imply elasticity values of the order of –0.4 to –0.7 for the March 1971 fare increase—a somewhat higher elasticity than those estimated for the March 1972 fare cut. However, the models calibrated on the data through February 1973 (Groups C and D, shown below the broken line in Table 6) imply markedly lower fare elasticities for the March 1971 increase, of the order of –0.15 to –0.3. The reason for this is not difficult to determine. The estimation of the Group C and D equations is heavily influenced by the effects of the large MARTA fare reduction, which dominates the much smaller 1971 increase. These equations provide a good fit to the post-March 1972 data at the expense of being a poorer fit (than the Group A and B calibrations) to the pre-MARTA experience. One therefore con-

FARE ELASTICITIES FOR THE MARCH 1971 FARE INCREASE

	Revenue passenger volumes			Implied fare elasticity		
	3 months, Mar '71 to May '71	6 months, Mar '71 to Aug '71	12 months, Mar '71 to Feb '72	η_3	η_6	η_{12}
	thousands	thousands	thousands			
Actual riders at 40¢ base fare	11,734	21,715	44,000			
Predicted riders at 35¢ base fare, from model:						
A4	12,439	23,187	46,790	-0.44	-0.49	-0.46
A5	12,631	23,519	47,599	-0.55	-0.60	-0.59
B3	12,737	23,582	47,670	-0.61	-0.62	-0.60
B4	12,818	23,741	47,949	-0.66	-0.67	-0.64
C1	11,976	22,479	45,605	-0.15	-0.26	-0.27
C2	12,028	22,508	45,408	-0.19	-0.27	-0.24
D1	11,991	22,343	45,707	-0.16	-0.21	-0.29
D2	11,994	22,345	45,696	-0.16	-0.21	-0.28
D3	12,025	22,390	45,521	-0.18	-0.23	-0.25

TABLE 6

cludes that, for the 1971 fare change, the higher elasticities implied by the Group A and B models are to be preferred to the lower values implied by the Group C and D equations.

RIDERSHIP AND THE LEVEL OF SERVICE

This analysis proved less successful in identifying the effects of service changes on ridership than it did in identifying fare change effects. There are two principal reasons for this. First, the variable TVM is an inadequate measure of the level of service as it is perceived by the individual passenger. Partly as a consequence of this, the coefficient of TVM does not play a significant role in most of the model formulations in which the variable was entered. In only three of the equations summarized in Tables 2, 3, and 4 is the coefficient of TVM significantly different from zero at the five percent level.

Secondly, although after MARTA assumed control of the system an extra 30 percent of vehicle miles (on an annual basis) had been added by February 1973, the additions were made on a gradual basis over the year. This means that there are hardly any individual changes of sufficient magnitude to allow a meaningful examination of the effects of that specific service improvement (in a manner akin to the one used to estimate the demand elasticities relating to specific fare changes). The one exception to this occurred too late in the data period to be assessed in this way.

Point elasticities of ridership with respect to vehicle miles operated were computed from equations A5, C2, and D3, the only ones with significant coefficients for the TVM variable. Using the values of the exogenous variables as they were for February 1972, the month of MARTA's takeover, equation A5 yields an elasticity value of +1.13, equation C2 gives a value of +0.33, and equation D3 implies an elasticity of +0.31[3]. However, since model A5 is estimated from a data base which does not include any of the post-March 1972 experience (which is when the major service improvements were made), it appears reasonable to accept a supply elasticity of roughly +0.3 as implied by models C2 and D3.

In summ[illegible]ppears that the service i[illegible] implemented by MA[illegible]1972 and February[illegible] 1.6 million more revenue passengers than would have otherwise been the case, given the MARTA fare reduction. On this basis, a full year's operation at the February 1973 supply level could be expected to generate some 3.0 to 4.5 million more revenue passengers than at the February 1972 level.

SUMMARY AND CONCLUSIONS

This analysis has confirmed that it is possible to model successfully the longitudinal variations in transit patronage in Atlanta (on a month-by-month basis) using a small number of explanatory variables. The fourteen linear model formulations estimated here provide a very good fit indeed to the Transit Authority's operating data over a three year time period which incorporate a fare change of a relatively large magnitude and significant improvements in service levels.[4]

For an increase in base fare from 35¢ to 40¢ in 1971, the fare elasticity appears to have been of the order of –0.45 to –0.7, and probably was close to –0.6. However, when the fare was reduced to 15¢ in 1972, the elasticity was roughly –0.15 to –0.2. In both cases, the demand was still changing in response to the fare change after three months, but appeared to have stabilized after six months.

Over the first twelve months of operation at low fare, the fare reduction appears to have added roughly 8.2 million revenue passengers to the 42.8 million revenue journeys which would otherwise have been made at the 40¢ base fare level, given the MARTA service improvements. This is an increase of just over 19 percent.

The cost to MARTA of these fare cuts, measured solely in terms of foregone revenue, is consequently a net of roughly $10 million per year, or somewhere between $1.00 and $1.25 per revenue passenger gained. This is, of course, not the total cost of the ridership growth because to the lost revenue needs to be added the incremental transit operating costs of carrying these additional passengers.

Over the first year of MARTA's operation of the system, a total of almost 2 million more vehicle miles were operated than in the preceding twelve month period. It is estimated that this supply increase added roughly 1.5 to 1.6 million more revenue passengers than would have otherwise been the case, given the MARTA fare reduction. This is equivalent to a demand elasticity with respect to vehicle miles of roughly +0.3. On this basis, a full year's operation at the February 1973 supply level could be expected to generate some 3.0 to 4.5 million more revenue passengers than at the February 1972 level.

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FOOTNOTES

1 All data manipulation and model estimation was carried out using PLANETS, a computer program developed by the Brookings Institution Social Science Computation Center for the analysis of economic time series data.

2 Here and throughout this paper, a "high" elasticity refers to one with a relatively large numerical value, disregarding the negative sign.

3 The magnitude of the variation in these estimates illustrates the inadequacy of TVM as an index of service provision.

4 Similar linear time series models have more recently been estimated for major fare and service changes in San Diego and Cincinnati (Kemp, 1974b), giving comparable levels of explanation of month-to-month variations in aggregate ridership.