THE EFFECT OF FARES ON TRANSIT DEMAND:
A CASE STUDY OF ATLANTA, GEORGIA

by
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Submitted in Partial Fulfillment
of the Requirements for the
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June, 1972

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Department of Urban Studies and Planning

Certified by .......................................................... Thesis Supervisor

Accepted by .......................................................... Chairman, Departmental Committee on Theses

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ABSTRACT

The Effect of Fares on Transit Demand:

A Case Study of Atlanta, Georgia

by

Richard W. Prather

Submitted to the Department of Urban Studies and Planning on May 12, 1972 in partial fulfillment of the requirements for the degree of Bachelor of Science.

Across the country transit fares have been steadily raising since 1950. In Atlanta, this trend was recently reversed. The transit fare was decreased from 40 cents to 15 cents. This thesis analyzes the effect of fares on transit ridership. Atlanta is used as a case study to show the general methodology available to evaluate fare changes.

By examining past studies, it is shown that transit demand is inelastic to fare changes. Fare changes in other cities show that fare elasticity differs by trip purpose, time of day, level of service, day of week and economic level of the trip maker. Analysis of the methodology used in Atlanta shows that better tools are needed to evaluate fare changes.

Thesis Supervisor: Ralph A. Gakenheimer

Title: Associate Professor of Urban Studies and Planning
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Chapter I
Introduction

On November 9, 1972, the voters of metropolitan Atlanta narrowly approved a one percent increase in the sales tax to finance a public transportation system. The backbone of the system will be 50 miles of rail rapid transit. Many political and business leaders consider this system a key to the solution of Atlanta's transportation problems. Indeed, many feel that unless a rail transit system is built, the region will not continue to prosper. To them the question was not whether Atlanta could afford to solve its transportation problems but whether it could afford not to. Atlanta is faced with problems similar to those of other major U.S. cities. They include increasing automobile congestion, declining transit ridership, raising transit fares, increasing air pollution, increasing demands for parking in the CBD and the problems of mobility faced by the young, the old and the poor.

An immediate result of the referendum approval was a decrease in transit fare from 40 cents to 15 cents on March 1, 1972. The 15 cent fare reflects a direct subsidy of operating costs. It is hoped that the new system will be so attractive in reduced travel time and reduced costs that many auto drivers will switch to transit and leave the expressways and major streets to those who must drive. This would decrease congestion and pollution while lessening the need to build more highways and parking spaces downtown. Planners are also looking to the new system to stimulate downtown activity and to revitalize the central
city. In many cities the central business districts have declined as population, employment and business activity moved from the central city to the suburbs. It is hoped that the proposed transit system will reverse this trend.

The citizens of Atlanta have very optimistic expectations of the benefits of the transit system. A great deal of the optimism is based on the hope that the system will be many more times attractive as the present system because of improvements in service and the decrease in fare. A fare reduction in a major U.S. city is very rare. In fact, transit companies are under continuous pressure to raise fares because of increasing costs and decreasing ridership. Fitch [1] points out that transit operators have no short run economic incentive to keep fares down and thereby maintain or increase passenger volumes. Short run demand for transit service is such that fare increases normally increase total revenues, in the short run, even though ridership declines. Fitch [2] reports that the median cash transit fare went from 10 cents in 1950 to 15 cents in 1955 and to 20 cents in 1961. The fare range was 5-17 cents in 1950, and 10-30 cents in 1961. Between 1961 and 1972 fare increases have continued.

The objective of this thesis will be to analyze, on an exploratory level, the effect of fares on transit ridership. Atlanta is used as a case study to show the general methodology available to evaluate fare changes. The scope of this thesis is not comprehensive at all. Time and resources do not allow such a treatment of the topic. It is hoped that the analysis presented shows the need for much more research in this area. Chapter II summarizes the history of transit planning in
Atlanta showing how the present fare structure was developed. In Chapter III the effect of fares on transit demand is examined using the results of past studies. Chapter IV shows the method of analysis used in Atlanta to forecast transit demand. Conclusions and suggestions of areas for further study are presented in Chapter V.
Chapter II
The History of Transit Planning in Atlanta

Prior Transit Plans

The concern for rapid transit transportation in Atlanta can be traced back to 1954. In that year the Atlanta Region Metropolitan Planning Commission (ARMPC) released its four county plan, Now for Tomorrow. The following is an excerpt from that report:

Currently the citizens of the Atlanta area are dependent on rubber tired buses to satisfy public transportation needs. Within a few years, however, we will require some type of high speed mass transportation to supplement the bus system and serve our fast growing suburbs. [1]

In 1959, ARMPC released three more reports that dealt with transportation. They were Crosstown and By-pass Expressways, Access to Central Atlanta, and a report giving general facts on rapid transit. [2] These culminated in the 1962 report Comprehensive Plan on Rapid Transit. This report recommended short and long range rapid transit plans. The basic design was a series of spokes and spurs radiating in all directions from a CBD transit center.

In 1962, the engineering firm of Parsons, Brinckerhoff, Quade and Douglas (PBQD), under contract with the Metropolitan Atlanta Transit Commission, examined the feasibility of a regional transit system. PBQD recommended a system similar to the ARMPC proposal.

Favorable attitudes toward a transit system were growing rapidly. In 1965 the Georgia legislature passed a bill authorizing a transit district in the metropolitan Atlanta region. Also authorized was the creation of the metropolitan Atlanta Rapid Transit Authority (MARTA).
MARTA was authorized to issue bonds, and to plan, construct, and operate a transit system.

MARTA is a public agency. The governments of the four counties and the city of Atlanta appoint its ten directors. MARTA has no taxing power or eminent domain powers. The five governments approve MARTA's budget and supply the local portions of MARTA funds to match state and Federal grants.

In 1967, the firm of Parsons, Brinckerhoff-Tudor-Bechtel, (PBTB) under contract with MARTA, updated the 1962 plan "to account for land use, patronage, and other changes which took place during the five year interval." [3] The new plan called for a 44 mile rail transit system that would cost a total of $600 million. The construction of the system required voter approval. In the fall of 1968 MARTA presented the PBTB plan to the voters in a referendum. It was narrowly defeated. Most observers attributed the defeat of the plan to its reliance on a property tax increase, the uncertainty of Federal funding, the speed with which it was developed and "sold" and the overwhelming opposition of Atlanta's Black Community. [4]

The referendum's defeat forced Atlanta to re-evaluate its whole transportation program. The Atlanta Area Transportation Study (AATS) served as the medium for that re-evaluation. The AATS had been functioning since 1962 as a planning element of the State Highway Department. It began as a regional planning study administered by the Bureau of Public Roads (now Federal Highway Administration). Its main concern was estimating future needs for new highways.
1967, the AATS was reconstituted as an informal regional transportation planning body. Its new form included a policy committee consisting of the heads of local governments (city and county), the heads of the three agencies capable of providing transportation facilities and services (the State Highway Department, MARTA, and the Atlanta Transit System), and the Chairman of the Board of ARMPC. The Policy Committee was supported by a Technical Coordinating Committee which included technicians from all the participating agencies.

The first AATS regional transportation plan was unveiled in April, 1969. The plan included a $2 billion package of proposals for an entire regional transportation system; including completion of the expressway system, upgrading of major arterials, and a combined 66 mile rail-busway system. The transit portion of this plan consisted of a $475 million program of rapid rail and busway construction. (A busway is simply a bus operating on its own private right of way.) This included 64 miles of private right of way routes, with 10 miles for rapid rail and 54 miles for busways, and an expanded local and feeder bus network. It was estimated that this system would carry 10 to 15 thousand more passengers per day than would have been carried by MARTA's 1968 system. Its construction cost would have been 17% less than MARTA's cost. Both systems served basically the same corridors. The major difference was the AATS's systems heavy reliance on buses to provide parts of the line-haul service.
MARTA's 1971 Rapid Transit System

Figure 1
The Present Plan

By the Fall of 1969, MARTA had begun to question the technical and political feasibility of a busway system. The MARTA staff knew of no busway system in operation at that time and were pessimistic of the technical problems of building an "untried" system. At that time many people in Atlanta considered busways second-rate to rail rapid transit. Therefore, it was reasoned, a busway system would be harder to sell in a referendum. These concerns caused MARTA to revise the transit plans.

By November, 1971, MARTA was ready to present its transit plan to the voters. MARTA's new system called for 56 miles of rapid rail transit and 14 miles of rapid busways at a cost of $1.4 billion. The corridors to be served were basically the same as the 1968 MARTA system and the 1969 AATS system. The major difference from the 1968 system was the use of busways and an expanded rail system. The referendum narrowly passed in Fulton and DeKalb County but was defeated in Clayton and Gwinnett County. The package that was approved by the voters included the rapid transit plan, improved bus service, a one percent sales tax and a 15 cent fare.

Development of the Fare Structure

It is difficult to document the origin of the idea for a 15 cent fare structure. It appears that MARTA made reference to a "very low fare of about 15 cents" in some of its public relations materials. This figure remained in the public's mind. During the Summer of 1971
a memo written by the Citizen's Transportation Advisory Committee contained the following:

It has been apparent for some time now that a number of citizens expect that a flat rate of 15¢ will be charged, at least initially, for any transit service operated by the Metropolitan Atlanta Rapid Transit Authority. Readjusting public sentiment on this starting fare appears to be extremely difficult. [5]

Also during that Summer, the Atlanta Coalition on Current Community Affairs (a coalition of Black organizations) presented a list of crucial issues to the MARTA board. [6] One of the key issues in that list was a guarantee from MARTA that its objective was a 15 cents transit fare for 10 years. The board's reply to that issue was:

On June 7, 1971, the Board adopted a resolution specifying a subsidized fare of 15 cents for the initial operation of Atlanta Transit System. It was impractical then as now to say with certainty how long such a fare could prevail, since most of the related engineering and financial aspects are not final. A decision on the fare will be made when the system is adopted in August. For every dollar collected through fares, three dollars will be available for construction assuming 2/3 Federal matching funds. The Board wishes to present a fare structure that will not constrict the solution of community transportation problems. [7]

Thus, public pressure was on MARTA to have a 15 cent fare for as long as possible. The fare structure that MARTA finally adopted was a 15 cent fare (without transfer charges) for the first seven years and a 5 cent increase per year until the tenth year when the fare would be 30 cents. Thereafter, the fare will be maintained at as low a rate as possible considering all other relevant matters.

The range of fare structures existing today in America can be grouped into three categories: [8]
(1) Flat-fare plans where a uniform charge applies to any ride within the service area.

(2) Zone-fare plans where the service area is divided into segments, with the basic fare applicable to a one-zone ride and additional fare increments added for each subsequent zone traversed.

(3) Point-to-point fare plans where individual fares are determined between each two points on the system, with the amount of fare varying with the length of ride.

These three approaches are not mutually exclusive.

The decision on the fare structure involved political and economic issues. Remembering the 1968 referendum defeat, MARTA wanted to make the transit package as attractive as possible. Politically, MARTA had to develop a fare structure that would not cause defeat of the referendum. The fare structure also had to be economically feasible. It would be foolish to set fares at a level so low that financing of a viable transit system would be impossible. Therefore, an understanding was needed of the effect of the fare structure on ridership and revenues.

The adopted fare structure adequately addressed the political issue; as evidenced by the successful referendum. The economic issues, however, remains a bit fuzzy. The analysis done before the referendum did not adequately consider the effect of the adopted fare structure on transit ridership and revenues. More importantly, no analysis was made of alternative fare structures. Realizing that public sentiment
would be difficult to readjust concerning a 15 cent fare, the issue became how long to maintain the 15 cent fare. Very little public discussion was given to issues like extra fares for long trips, zone fares or reduced fares for short trips. No analysis was done on the effects of such policies on ridership and revenues.

In order to develop a fare structure which would generate the desired amount of revenue it is necessary to first understand how ridership and revenue vary as fares are raised or lowered. The next chapter examines the relationship between fares and transit demand.
Chapter III
The Effect of Fares on Transit Demand

Transit Demand

In order to identify the relationship between fares and transit ridership, an understanding of transit demand is needed. The demand for transit is dependent on the level of service provided by transit and the level of service provided by competing modes of travel. For transit, auto is the primary competing mode. Level of service is composed of such things as out of pocket costs, waiting time, travel time, walking distances, comfort and convenience. Transit demand is negatively related to the cost and travel time of transit and positively related to the cost and travel time of auto. Domencich, Kraft and Valette [1] developed a model in which transit demand was a function of the number of individuals in the origin zone and their socio-economic characteristics, the level of activity and other relevant socio-economic and land-use characteristics in the destination zone, together with the travel times and costs of transit and auto. Thus, transit demand is related to a wide range of explanatory variables.

In considering the effect of fare changes, the concept of demand elasticity is useful. Demand elasticity is the percentage change in the number of trips demanded for a given mode in response to a one percent change in one of the explanatory variables, assuming all other explanatory variables remain constant.

\[ E_f(R) = \text{Elasticity of ridership with respect to fare} = \frac{\delta R/R}{\delta f/f} = \frac{f}{R} \frac{\delta R}{\delta f} \]

\( f = \text{transit fare} \)

\( R = \text{number of transit riders} \)
If the absolute value of $E_f(R)$ is less than one, then ridership is inelastic with respect to changes in fare. Ridership is elastic with respect to fares if the absolute value of $E_f(R)$ is greater than one.

Previous Studies

The relationship between fares and transit ridership has been reported in several papers. [2] Kraft and Domencich [3] concluded that transit demand is very inelastic with respect to changes in fares. They report fare elasticities of $-0.3$ and $-0.2$ for shopping and work trips respectively. Table 1 shows the results of fare changes in fifteen cities. The elasticities range from $-0.08$ to $-0.40$. In each case, however, transit ridership is inelastic with respect to fares. Three fare changes in Atlanta indicate elasticities of $-0.28$, $-0.38$ and $-0.40$.

Work done by Carstens and Csanyi [4] helps to explain some of the differences in fare elasticities among cities. They found in their study of transit in Iowa that fare elasticity depends on the level of service of the transit system. Annual revenue miles of transit service per service area resident was used as the measure of level of service. Transit ridership tends to be more sensitive to fare changes at low levels of service. At high levels of service they found elasticities between $-0.3$ and $-0.4$ depending on the city size. Several cities had quite low levels of service. Iowa City was one of those cities. The fare there was decreased from a base fare of 25 cents to a uniform rate of 10 cents in 1966. Immediately transit
### Fare Changes

<table>
<thead>
<tr>
<th>City</th>
<th>Date</th>
<th>From To</th>
<th>% Fare Change</th>
<th>% Rider-ship Change</th>
<th>Fare Elasticity</th>
</tr>
</thead>
<tbody>
<tr>
<td>San Francisco</td>
<td>June 1952</td>
<td>10 - 15</td>
<td>+50</td>
<td>-9.18</td>
<td>-0.18</td>
</tr>
<tr>
<td>New York City</td>
<td>July 1953</td>
<td>10 - 15</td>
<td>+50</td>
<td>-10.0</td>
<td>-0.20</td>
</tr>
<tr>
<td>New York City (Bus)</td>
<td>Jan. 1954</td>
<td>10 - 13</td>
<td>+13.3</td>
<td>-10.0</td>
<td>-0.30</td>
</tr>
<tr>
<td>Philadelphia</td>
<td>Jan. 1954</td>
<td>15 - 18</td>
<td>+20</td>
<td>-2.8</td>
<td>-0.14</td>
</tr>
<tr>
<td>Boston (Surface) (Rapid)</td>
<td>Oct. 1955</td>
<td>13 - 15</td>
<td>+6.5</td>
<td>-</td>
<td>-0.19</td>
</tr>
<tr>
<td>Chicago</td>
<td>July 1957</td>
<td>20 - 25</td>
<td>+25</td>
<td>-7.5</td>
<td>-0.30</td>
</tr>
<tr>
<td>Cincinnati</td>
<td>July 1957</td>
<td>20 - 25</td>
<td>+25</td>
<td>-6.0</td>
<td>-0.24</td>
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<tr>
<td>Portland</td>
<td>Feb. 1958</td>
<td>20 - 25</td>
<td>+25</td>
<td>-7.0</td>
<td>-0.28</td>
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<tr>
<td>Connecticut Co.</td>
<td>June 1958</td>
<td>15 - 20</td>
<td>+33.3</td>
<td>-9.3</td>
<td>-0.28</td>
</tr>
<tr>
<td>Baltimore</td>
<td>Oct. 1958</td>
<td>20 - 25</td>
<td>+25</td>
<td>-2.0</td>
<td>-0.08</td>
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<tr>
<td>Atlanta</td>
<td>Oct. 1963</td>
<td>20 - 25</td>
<td>+25</td>
<td>-7.0</td>
<td>-0.28</td>
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<tr>
<td>Salt Lake City</td>
<td>Dec. 1963</td>
<td>20 - 25</td>
<td>+25</td>
<td>-3.0</td>
<td>-0.12</td>
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<tr>
<td>New York City</td>
<td>July 1966</td>
<td>15 - 20</td>
<td>+33.3</td>
<td>-6.0</td>
<td>-0.18</td>
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<tr>
<td>Cincinnati</td>
<td>Dec. 1968</td>
<td>25 - 30</td>
<td>+25</td>
<td>-7.3</td>
<td>-0.29</td>
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<tr>
<td>Chicago</td>
<td>Dec. 1968</td>
<td>30 - 40</td>
<td>+33</td>
<td>-6.1</td>
<td>-0.18</td>
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<tr>
<td>Pittsburgh</td>
<td>Jan. 1969</td>
<td>30 - 35</td>
<td>+16.7</td>
<td>-5.5</td>
<td>-0.33</td>
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<tr>
<td>Atlanta</td>
<td>Aug. 1969</td>
<td>30 - 35</td>
<td>+16.7</td>
<td>-6.3</td>
<td>-0.38</td>
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<tr>
<td>New York City</td>
<td>Jan. 1970</td>
<td>20 - 30</td>
<td>+50</td>
<td>-4.7</td>
<td>-0.09</td>
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<tr>
<td>Kansas City</td>
<td>Jan. 1970</td>
<td>35 - 50</td>
<td>+43</td>
<td>-13.2</td>
<td>-0.31</td>
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<tr>
<td>Atlanta</td>
<td>March 1972</td>
<td>40 - 15</td>
<td>-62.5</td>
<td>+25.0</td>
<td>-0.40</td>
</tr>
</tbody>
</table>

Table 1

Transit Fare Changes

ridership nearly doubled and continued to increase gradually until the ridership increase was more than 100% after the reduced fare had been in effect for a year. The level of service had risen during that period. Part of the ridership increase was possibly caused by the change in service level. A comparison of ridership in the fourth quarters of 1965 and 1967 indicated an increase of 127% in ridership. Considering the effect of the service change, the fare decrease of 48% caused a 98% increase in ridership. That meant a fare elasticity of -2.0. Carstnes and Csanyi explained that different service levels caused differences in elasticities because many transit riders in Iowa had a choice of travel mode and traveled by other means when faced with fare increases on a system with low levels of service. Only when travel could be made with shorter waiting times and reduced walking distances (implied by high levels of service) was transit ridership fare inelastic.

In calculating the impact of a fare increase on the proposed BARTD system, Curtin [5] reasoned that, because of the superior quality of service and passenger amenities represented in rapid transit as compared to existing forms of transit in San Francisco, the fare elasticity for BARTD would be lower than that for existing routes and services. This was based on the belief that passengers would be willing to pay more for superior service.

Work done by Lassow [6] on the fare increase of 1966 in New York City indicates that elasticities differ by trip purpose, time of day, day of week, and economic level of the trip maker. Table 2 shows the gross effects of the fare change. Table 3 shows the effects of the fare change on subway ridership by time of day.
Gross Effects of Fare Change

Percentage loss of ridership

<table>
<thead>
<tr>
<th></th>
<th>total</th>
<th>weekday</th>
<th>saturday</th>
<th>sunday</th>
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<tbody>
<tr>
<td>subways</td>
<td>2.4</td>
<td>1.9</td>
<td>4.1</td>
<td>1.0</td>
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<tr>
<td>buses</td>
<td>10.0</td>
<td>9.5</td>
<td>11.0</td>
<td>10</td>
</tr>
</tbody>
</table>

Elasticity of Ridership

<table>
<thead>
<tr>
<th></th>
<th>total</th>
<th>weekday</th>
<th>saturday</th>
<th>sunday</th>
</tr>
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<tbody>
<tr>
<td>subways</td>
<td>-.07</td>
<td>-.06</td>
<td>-.12</td>
<td>-.03</td>
</tr>
<tr>
<td>buses</td>
<td>-.3</td>
<td>-.28</td>
<td>-.32</td>
<td>-.3</td>
</tr>
</tbody>
</table>

Table 2

Subway travel is composed of a larger proportion of work trips than bus travel. Thus the lower elasticities for subway ridership agree with the results obtained by Kraft and Domencich, i.e., fare elasticity for work trips is less than that for non-work trips. Bus trips are shorter, less work oriented and may be more casual. This suggests that bus travelers are more prone to eliminate trips or to substitute walking or taxi trips.
Effects by Time of Day
(subway only)

<table>
<thead>
<tr>
<th>Time</th>
<th>% Ridership Loss</th>
<th>Elasticity</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 a.m. - 10 a.m.</td>
<td>2.4</td>
<td>-.06</td>
</tr>
<tr>
<td>10 a.m. - 4 p.m.</td>
<td>8.0</td>
<td>-.24</td>
</tr>
<tr>
<td>4 p.m. - 7 p.m.</td>
<td>5.0</td>
<td>-.15</td>
</tr>
<tr>
<td>7 p.m. - 11 p.m.</td>
<td>14.6</td>
<td>-.44</td>
</tr>
<tr>
<td>11 p.m. - 7 a.m.</td>
<td>3.7</td>
<td>-.11</td>
</tr>
</tbody>
</table>

Table 3

The different fare elasticities for different days of the week indicate how elasticities vary by trip purpose. Saturday and Sunday trips are generally more shopping, social and recreational oriented trips. Thus the fare elasticities for these days are greater than that for the weekdays. Sunday subway ridership was very inelastic. Lassow speculated that Sunday subway riders were mainly workers in service industries and round the clock operations and people traveling for social and recreational purposes. Thus the small decrease in ridership was due to the fact that the workers had to travel and the others may not have had autos and were not deterred by the higher fares because their trips may have been for special occasions and involving long trips by the entire family. This was only speculation since no data existed to offer any explanations.
The peak periods had the lowest elasticities. The largest elasticity was for the evening hours which have the highest proportion of social and recreation trips. The differences in elasticities for time of day appear to be caused by differing proportions of trip purposes.

The effect of the fare increase on lower income areas is given in Table 4. A comparison with Table 3 shows that the impact of the fare increase was greater for lower income areas.

### Effects of Fare Change on Lower Income Areas
(subway only)

<table>
<thead>
<tr>
<th>Time</th>
<th>% Ridership Loss</th>
<th>Elasticity</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 a.m. - 10 a.m.</td>
<td>4.5</td>
<td>-.13</td>
</tr>
<tr>
<td>10 a.m. - 4 p.m.</td>
<td>9.3</td>
<td>-.28</td>
</tr>
<tr>
<td>4 p.m. - 7 p.m.</td>
<td>8.0</td>
<td>-.24</td>
</tr>
<tr>
<td>7 p.m. - 11 p.m.</td>
<td>19.1</td>
<td>-.57</td>
</tr>
<tr>
<td>11 p.m. - 7 a.m.</td>
<td>13.1</td>
<td>-.39</td>
</tr>
</tbody>
</table>

Table 4
Elastic vs. Inelastic

All of the studies indicate that transit ridership is inelastic to fare changes. The transit industry's role of thumb is a fare elasticity of -0.3. The distinction between elastic and inelastic demand is important. If transit demand is elastic with respect to fares, then a decrease in fare (without a change in service) will increase ridership, and gross revenues. Net revenues may or may not increase depending on the increase in costs caused by the additional riders. An increase in fare will decrease ridership, gross revenues, and net revenues. If, however, transit demand is inelastic with respect to fares, then an increase in fare (without a change in service) will increase the gross and net revenues but decrease ridership. A decrease in fares will increase ridership but decrease gross and net revenues. The size of the demand elasticity is therefore important in determining the financial effect of a fare change on the transit system. The three fare changes shown for Atlanta in Table 1 all indicate inelastic demand.

The Atlanta Fare Reduction [6]

The 1972 reduction applied to about 83% of the system's riders. The remaining 17% use special services, such as school buses, and their fares remained the same. There was a 25% increase in ridership, after one week, in the group receiving the fare reduction. Overall there was an 18.5% increase in ridership. The increase was enough to warrant purchase of 20 used buses to meet emergency conditions of overcrowding on some routes.
Further analysis by MARTA indicates that a substantial increase in riders has occurred during off-peak hours and on weekends and that a significant increase in short distance riding has occurred. The peak period increase was 5 to 6%; indicating an elasticity of about -0.08. MARTA attributes the small increase in peak hour riders to the uncertainty of the continuation of the 15 cent fare. (Until a court case is settled it is uncertain how long MARTA can maintain the 15 cent fare.) It is reasoned that commuters are not willing to give up parking spaces or car pool arrangements until the lower fare is permanently established. The significant increase in short distance riding supports the theory that many potential riders prefer to walk limited distances rather than use transit if fares are relatively high. Also, the difference between transit fares and taxi fares is not substantial for short trips, especially when two or more people are traveling together.

The work done by Kraft and Domencich suggests that most of the increase in peak hour transit work trips is diverted from automobile travel. For non-work trips, however, there is little diversion from autos. Most of these additional transit trips are induced trips. The fare reduction probably caused people to increase their total number of non-work trips. It is unlikely that a fare reduction could cause people to increase their total number of work trips.

Except for Atlanta and Iowa City, all of the fare changes involved increases in the fare. Most people implicitly assume that for a given city, if the fare is increased or decreased by X percent, then ridership will decrease or increase by y percent. It is not intuitively
obvious that the fare elasticity for fare increases is the same as the one for fare decreases. The public may react both qualitatively and quantitatively different in each case. This question needs to be considered further.

As pointed out earlier, the issue that MARTA had to resolve was the length of time to maintain the 15 cent fare. The main criteria for determining this would appear to be the amount of revenue estimated for future years. The next chapter examines the methodology used by MARTA to estimate future ridership and revenues. Both have been shown to be sensitive to the fare elasticity.
Chapter IV
MARTA's Methodology

Traditional Approaches to Transit Demand Estimation

Before outlining the methodology used by MARTA, it is useful to discuss the traditional approaches used to estimate transit demand. Many traditional techniques for estimating transit demand exist. Generally, they can be grouped into the following diversions:

1. Direct generation of transit trips
2. Modal split
   a) Trip-end models
   b) Trip-interchange models.

Direct Generation [1]

The direct generation approach involves estimating transit trips directly from basic factors such as automobile ownership and residential density. This method has been used by small urban area transportation studies. Transit person trips are generated directly either with total person trips or auto driver trips by purpose. If total person trips are generated, automobile occupancy factors can be used to convert the person trips not using transit into auto driver trips. The transit and the auto-driver trips can then be distributed and assigned. There is no way to assess the impact of changes in transit usage on the number of auto trips if auto-driver trips are generated instead of total person trips because each is forecast independently. This approach would be justified for a small urban area having little transit
usage at present and in the forecast year. This technique ignores the question of the relative cost of transit versus automobile trips. (See Figure 2.)

Modal Split [2]

The modal split method of approaching transit demand focuses on the division of trips between competing modes of transportation. The techniques under this approach all presuppose some independent technique of estimating the total number of trips that will be made by all modes in the system.

Trip-End Models

Trip-end or predistribution models estimate the proportion of total person trips by transit before trip distribution. Automobile occupancy factors are applied to the auto person trips to produce auto-driver trips. The transit and auto-driver trips ends are then distributed and assigned. Assignment is independent, i.e., transit trips are assigned using only the transit network and auto trips are assigned using only the highway network. (Figure 3)

Trip-end models usually make primary use of the characteristics of the trip makers and their residence zones. These models are forced to rely on weak service measures because the most effective measures of transit service are related to the specific zonal interchanges which are not calculated at the time of the split.
In summary, a trip-end model uses socio-economic characteristics and, sometimes, a general accessibility index to the region as a whole, to explain choice of mode. These models are strongly tied to existing and historic transit service levels. Trip-end mode split models were developed in the earliest transportation studies where the main objective was the prediction of and planning for highway transportation.

Trip-Interchange Models

Trip-interchange or post distribution models allocate the trips among the various modes after trip distribution. The theory underlying this model is that the total number of people moving between an origin and a destination zone make up a travel market. The available modes complete for the market and, depending on their relative competitive position, obtain a portion of it.

Total person trips are generated by purpose and distributed, usually on the highway network. Next, the modal split model is applied to determine the proportion of each trip interchange that will occur by transit. Auto occupancy factors are applied to the auto person trips. The transit and auto-driver trips are then assigned to their respective networks.

Trip-interchange models allow better reflection of the effects of transit service differentials that exist between different trip interchanges. It uses socio-economic characteristics and accessibility measures between specific zonal pairs.
Figure 2
Generalized Diagram of the Direct Generation of Transit Trips Approach

Figure 3
Generalized Diagram of a Trip-end Modal Split Model

Trip-interchange models were developed as planners began to recognize the important of public transportation in urban travel. These models are more sensitive to characteristics of the transportation system. In addition, the trip-interchange sequence appears to be more realistic than the trip-end sequence. (See Figure 4.)

The Atlanta Modal Split Model

The modal split model used by MARTA was developed in 1968 by Alan Voorhees and Associates for the AATS. [3] It was a trip interchange model. Previously, the AATS had used a trip-end model. A new model was developed because "the mode choice model developed by the AATS staff had been intended for more generalized estimates of future transit usage in the context of future highway planning. Use of the model to test alternative transit systems was not envisioned." [4]

The interchange model consisted of a set of diversion curves. The variables used in the model are: average family income, employment density, and equivalent travel time differences \([\text{transit line haul time} - \text{highway line haul time}] + 2.5 [\text{transit excess time} - \text{highway excess time}]\). There are four levels of employment density, nine ranges of family income and ten classes of equivalent travel time differences. (See Table 5) The trip purposes used in the modal are home based work, home based other and non-home based. Figure 5 is an example of the curves.

By use of past travel surveys, mode choice percentages were found for each cell defined by the four levels of employment density, nine
Figure 4

Generalized Diagram of a Trip Interchange Modal Split Model

ranges of family incomes, and ten classes of equivalent travel time differences. There are 360 different cells. The mode choice program reads the input trip tables, the values of the input variables for the trip interchanges and selects the percent transit relevant to the particular interchange.

The major weakness of the model in the context of this thesis is the absence of any measure of the relative cost of transit versus auto trips. The explanation for this omission is given in the report. [5]

Running time differences and cost differences were shown to be of only marginal significance by the preliminary regression analysis. In the case of running time differences, this is primarily because bus speeds are fairly constant throughout the urban area and quite low compared to auto speeds, hence, there is very little variance in transit usage with respect to running time holding all other factors constant. The same reasoning may be applied to cost differences. It should be noted that the cost difference employed here does not include parking cost since 1961 parking cost data was unavailable. This is a serious deficiency as parking cost is typically one of the most significant factors in mode split. The strong showing of employment density is almost surely due to the high correlation of parking cost with employment density -- employment density is, in effect, a surrogate for parking cost. In spite of the poor showing of running time differences and cost differences, it is essential that running time differences be included in some way and desirable that cost differences be included. Running time difference is essential to the evaluation of alternative transit systems which have different operating speed characteristics. Inclusion of cost differences would permit study of alternative fare structures at some future date. (emphasis added)

At the time of development of the model, there was not an important reason to include cost variables since changes in fare structure were not a part of any of the transit proposals. In 1971, however, this omission was crucial since changes in fare structure were important parts of the transit analysis. What effect would the
ATLANTA MODE CHOICE CURVES
purpose: Home Based Work
Employment Density between 6.5 and 25, by Income Strata
0-3,000
3-4,000
4-5,000
5-6,000
6-7,000
7-8,000
8-10,000
10-12,000
Equivalent Time Difference

Figure 5
Variable Strata

<table>
<thead>
<tr>
<th>Gross Employment Density (persons/gross acre)</th>
<th>Average Family Income (Dollars)</th>
<th>Equivalent Time Differences (in minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00 - 1.00</td>
<td>- 3,000</td>
<td>- 0.0</td>
</tr>
<tr>
<td>1.01 - 6.50</td>
<td>3,001 - 4,000</td>
<td>1.00 - 10.00</td>
</tr>
<tr>
<td>6.51 - 25.00</td>
<td>4,001 - 5,000</td>
<td>11.00 - 20.00</td>
</tr>
<tr>
<td>25.01 - 99.00</td>
<td>5,001 - 6,000</td>
<td>21.00 - 30.00</td>
</tr>
<tr>
<td></td>
<td>6,001 - 7,000</td>
<td>31.00 - 40.00</td>
</tr>
<tr>
<td></td>
<td>7,001 - 8,000</td>
<td>41.00 - 50.00</td>
</tr>
<tr>
<td></td>
<td>8,001 - 8,000</td>
<td>51.00 - 60.00</td>
</tr>
<tr>
<td></td>
<td>10,001 - 12,000</td>
<td>61.00 - 70.00</td>
</tr>
<tr>
<td></td>
<td>12,001 - 99,000</td>
<td>71.00 - 80.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>81.00 - 990.00</td>
</tr>
</tbody>
</table>

Table 5

Various fare structures have on ridership? This question was impossible to answer using only the modal split model for analysis.
MARTA's Analysis

Since the modal split model used by MARTA was totally insensitive to cost differences between transit and auto travel, one would suspect that MARTA adjusted the results of the modal split analysis to account for the fare reduction. Unfortunately, this was not done.

Transit estimates were done for the years 1983 and 1995. The total travel demand in 1983 for each trip purpose was taken exactly as estimated by the AATS. The transit share of the trips for 1983 was determined by applying the modal split model to the total 1983 travel demand. Transit travel times were determined from the assumed 1983 transit network and auto travel times were obtained from the proposed AATS regional highway system for that year. The 1983 socio-economic forecasts used were developed by ARMPC. Line and station loads were obtained by assigning transit trips to the assumed 1983 transit network.

A somewhat different process was used to forecast 1995 transit trips. First, the modal split model was applied to the total 1983 travel demand under 1995 transportation system and socio-economic conditions. The figure obtained, it was reasoned, depicted a transit demand at the 1983 absolute volume level, but under the relative transportation and socio-economic conditions estimated for the region in 1995. The Fratar method was then used to produce the actual transit trips for 1995 (i.e., the figures were factored by the growth in employment and population of each zone that was estimated to occur between 1983 and 1995). Figure 6 shows the process used for 1983 and
1995. Once estimates were obtained for 1983 and 1995, estimates of patronage were made for intervening years within the span of the financing plan. These interpolated figures formed the basis of the annual fare revenue estimates. The figures were not adjusted to reflect the anticipated effects of the fare reduction. Table 6 shows the unadjusted results for 1983.

Travel by Mode and Purpose, 1983  
(Daily Weekday Trips)

<table>
<thead>
<tr>
<th>Trip Purpose</th>
<th>Transit Trips</th>
<th>%</th>
<th>Auto Trips</th>
<th>%</th>
<th>Total Trips</th>
</tr>
</thead>
<tbody>
<tr>
<td>Home-based work</td>
<td>204,743</td>
<td>17.17</td>
<td>987,709</td>
<td>82.83</td>
<td>1,192,452</td>
</tr>
<tr>
<td>Home-based school</td>
<td>14,607</td>
<td>12.54</td>
<td>101,832</td>
<td>87.46</td>
<td>116,439</td>
</tr>
<tr>
<td>Home-based other</td>
<td>106,787</td>
<td>3.59</td>
<td>2,869,023</td>
<td>96.41</td>
<td>2,975,810</td>
</tr>
<tr>
<td>Non-home based</td>
<td>24,414</td>
<td>3.57</td>
<td>660,192</td>
<td>96.43</td>
<td>684,606</td>
</tr>
<tr>
<td>Total Trips</td>
<td>350,551</td>
<td>7.05</td>
<td>4,618,756</td>
<td>92.95</td>
<td>4,969,307</td>
</tr>
</tbody>
</table>

Table 6

As Chapter III indicated, a fare reduction would cause an increase in the total number of transit trips. The amount of increase would vary by trip purpose, time of day, day of week and economic level of the trip maker. In order to do micro level planning, such as station, it will be necessary for MARTA to consider the changes in travel that will occur. Inadequate facilities may result if this is not done.
Transit Forecasting Process

MODE CHOICE MODEL (AATS) → 1983 TRANSIT TRIPS → ASSIGNMENT PROGRAM → LINE + STATION LOADS ON 1983 TRANSIT NETWORK

1983 HIGHWAY TRAVEL TIMES → TRAVEL TIME ON 1983 TRANSIT NETWORK

1983 TRANSPORTATION ZONE SOCIO-ECONOMIC CHARACTERISTICS (FROM ARMPC)

TOTAL TRAVEL DEMAND, 1983 (AATS 1 FORECAST)

MODE CHOICE MODAL TRIPS SPLIT FOR 1995 CONDITIONS → FRATAR PROCESS → 1995 TRANSIT TRIPS

1995 HIGHWAY TRAVEL TIMES → TRAVEL TIME ON 1995 TRANSIT NETWORK

1995 TRANSPORTATION ZONE SOCIO-ECONOMIC CHARACTERISTICS

1995/83 POPULATION AND EMPLOYMENT GROWTH FACTORS → ASSIGNMENT PROGRAM → LINE + STATION LOAD ON 1995 TRANSIT NETWORK

Figure 6
The continuing phase of planning in Atlanta will require estimates on line and station loads. Those that presently existed are based on the modal split analysis that did not incorporate the cost differences between transit and auto. They underestimate the actual loads. The results of the New York City fare change show that use of a constant fare elasticity in adjusting the figures will be misleading. If the fare change in Atlanta was monitored extensively, it may be possible to estimate the fare elasticity as it varies by trip purpose, by time of day, by economic levels and by length of trip. Such information would add greatly to the reliability of the projected ridership.
Fares are perhaps the most sensitive aspects of a transit system, reflecting a balance between political considerations and the need for operating revenues. [1]

MARTA's experience clearly indicates that alternative fare structures have to be considered first from the standpoint of public acceptance and policy considerations and then evaluated to determine their effect on transit ridership and revenues. In Atlanta, public sentiment appeared very strongly in favor of a 15 cent flat fare. Proposals for higher fares or different structures may have caused defeat of the referendum. Given that the fare would be 15 cents, the issue that MARTA faced was how long to maintain the fare at that level. The fare plan proposed by MARTA was not based on analysis. It was rather, a compromise between those groups that wanted a 15 cent fare for 10 years and those groups that wanted it only for a short time span. It was a political decision with limited analysis.

A better evaluation of the effect of the adopted fare structure on ridership and revenues probably would not have affected the outcome significantly. The crucial obstacle that MARTA had to overcome was public acceptance. Since the 1968 referendum, a feeling of distrust had existed among many portions of the public toward MARTA. During the summer of 1971, there was the feeling among some people that MARTA was misinforming and misleading the public on many important issues in order to make the proposed transit system more attractive.
In such an atmosphere the public was not willing to accept the professional judgement of the MARTA staff without question. This made it even more difficult to readjust public sentiment on the starting fare, even if there were valid reasons for starting at a higher fare. Thus, better understanding of the fare elasticity would have enabled MARTA to make better estimates of future revenues but it would not have allowed them to make significant changes in the fare structure. Since the transit plan had to be approved by the voters, MARTA's ability to develop alternative fare structures was limited. The power of the vote forced the adopted fare structure to be based greatly on political feasibility. Had voter approval not been required, I am sure that a different fare structure would have been adopted. I am not sure, however, whether a better analysis would have been made.

Evaluation of Fare Structures

The use of a constant fare elasticity by the transit industry is adequate for gross predictions but may be misleading for line and station analysis. Past studies and recent experience in Atlanta indicate that the elasticity of transit ridership with respect to fare varies by trip purpose, time of day, level of service, day of week, length of trip and economic level of the trip maker.

The present framework for doing modal split analysis does not permit adequate evaluation of alternative fare structures. In Atlanta, the absence of a cost variable made the model totally insensitive to cost differences between auto and transit. Even when a cost variable
is included in a modal split model there are still problems. Model split models are calibrated with data on existing and past trends. In most cases, the range of cost data is too narrow to permit inferences to be made with any reliability as to the effects of alternative fare structures. Extrapolation out of the range of the data would be required.

Modal split models are concerned with the diversion of auto trips to transit. The aggregate models commonly used predict the percentage of total daily trips that will be made by transit for each set of trip interchanges. Modal split is determined independent of the total number of trips, which is determined independent of supply characteristics such as the price of the trip. The result is that the models do not account for induced trips that occur when fare is lowered or trips that are not made when transit fare is raised.

The choice of when to travel is not reflected in modal split models. The problem is that there is an absence of data or reliable estimates of the price cross-elasticity between peak and off-peak travel. The division of trips between rail transit and bus is overlooked by modal split models. This issue becomes important when the price of the two services differ. Thus modal split models allow only a limited analysis of fare structures.

If public acceptance and policy considerations can be overcome, a wide range of fare structures is available to transit companies. Most would be modifications of differentiation based on distance and differentiation between peak and off-peak service. With automatic
fare collection techniques as proposed for the San Francisco BARTD system there is even greater opportunity to apply varying fare structures. The proposed system for BARTD involves using tickets that have electric charges stored on them. [2] Each time a ticket is inserted into an automatic turnstile, some of the charge can be removed. This kind of system can allow different rates to be charged for different times of the day and for different length trips. Technically, devices that will allow more variations in pricing will be available in the future. It is difficult, however, to say what the political feasibility of the variations will be in the future.

Because of the limitations of conventional modal split models, new techniques need to be developed to evaluate fare structures. The development of such tools requires a better understanding of the effects of fares on transit ridership. Particularly important is more analysis of the difference in elasticity by trip purpose, time of day, level of service, day of week and economic level of the trip maker. Without such information, transit companies will remain reluctant to trying new and innovative ideas in transit pricing.
Footnotes

Chapter I

1. Fitch, Lyle C., Urban Transportation and Public Policy, Chandler Publishing Col, 1964

2. op. cit., p. 36

Chapter II


2. op. cit., p. 18

3. op. cit., p. 20


5. The Advisory Committee was a broadly based group of local citizens appointed by the heads of government of the City of Atlanta and each of the participating counties. The memo was written to state the committee's position on the fare question.


7. Metropolitan Atlanta Rapid Transit Authority, Letter to the Atlanta Coalition on Current Community Affairs, July 22, 1971

8. Simpson and Curtin, Coordinated Transit for the San Francisco Bay Area, October 1967, p. 64

Chapter III


2. All of the articles in Highway Research Record 213, Passenger Transportation, 1968

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   Kraft, D. and M. Wohl, "New Directions for Passenger Demand Analysis and Forecasting," Transportation Research, Volume 1, Number 3, 1967

   Lave, C., "Behavioral Approach to Modal Split Forecasting," Transportation Research, Volume 3, Number 4, December, 1969


4. *op. cit.* p. 4

5. *op. cit.* p. 23

Chapter V

1. Simpson and Curtin, *Coordinated Transit for the San Francisco Bay Area*, October 1967, p. 64

2. *op. cit.* p. 186
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