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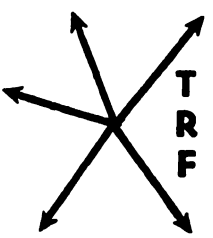

TRANSPORTATION RESEARCH FORUM

IN THE SPRING of 1972, the drivers of Transport of New Jersey Bus Company voted to go on a general strike. The largest bus network in the state of New Jersey—which is also the largest commuter bus service into New York City—was without any service to its users for more than two months. In total, about 350,000 daily passengers were directly affected. Of these, about 28,500 were daily commuters from New Jersey to Midtown Manhattan.

The other transit services of the Region were faced with the task of absorbing the abandoned Transport of New Jersey (hereinafter referred to as TNJ) riders. The highways leading to Manhattan, and the Trans-Hudson crossing facilities were also reporting extra traffic due to automobiles. While increased usage of some transit modes, highways and other auto facilities were reported in general, no effort was made by any public agency or operating authority, or any private transit operator to record officially the nature of these changes in commuting behavior.

The major catalyst for this investigation was the claim by the management of TNJ that the bus company, after the strike, had lost a significant proportion of its pre-strike commuter population. (1)†

An objective of this study was to gain some insight into the pattern of changes in journey-to-work transportation mode choice. Another was to measure some of the impact of the strike on competing transit modes. An important goal was to identify characteristics of permanent mode choice shifts by deprived former TNJ users.

The scope of this research was intended to acquire some feedback as to the reactions to the strike by the vast commuting population of Northern New Jersey. It was not designed to measure exact levels of ridership, or to examine complex socioeconomic and behavior variables that may have influenced commuters' choices in transportation.

The following discussion is a result of the research carried out within the functions of the Port Authority of New York and New Jersey after the resumption of TNJ bus services.[1]

SURVEY TECHNIQUE

A user-oriented survey was planned to determine some of the immediate and long-term effects of the strike. The immediate effects were thought to be indicated by the in-strike modal choice of the former TNJ commuters, while the longer-range changes were to be inferred from the post-strike mode choice. The information on post-strike transportation decisions was especially needed to verify or reject the claims of losses made by TNJ. (2)

Several alternative techniques were evaluated for use in the attempt to get inferences of what happened in the commuting behavior of Northern New Jersey. The definite need to survey modal choice patterns for the three strike periods (pre, in and post) was established. (The scope and logic of the survey are presented in Figure 1.)

SURVEY LOGIC

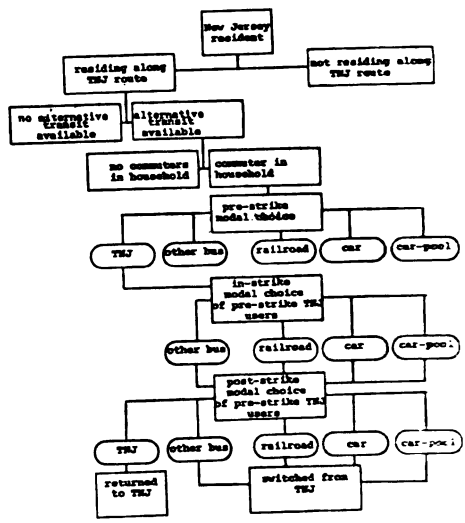

FIGURE 1

The next task was to produce a survey methodology which would optimize the needed results, with a fair rate of return, without prohibitive costs.

Some constraints on the survey design were the time limit given to complete the study and the acute shortage of manpower. There were four persons assigned to this investigation, who were to produce results within three months.

For these reasons, survey methods such as "on-board" and "toll-booth" data collections were rejected. The telephone —as a means for gathering information —was also considered, but it was abandoned, as it was soon realized that the desired respondents were not home during the regular daytime business hours. Since the study was to be independent of operating statistics, no data was collected from any public or private transit operator.

Naturally, it was impossible to gain information on all the commuters in New Jersey. Current figures indicate that in the area in question, there reside more than four million people. For this reason, it was decided to forego a large-

Modal Shift Behavior of Strike Affected Bus Commuters

*by Andrew Bata**

scale survey—taking random samples from a broad population base—and instead, to reach every household in a limited number of carefully chosen "survey target areas."

The "target areas" were carefully selected so that they would be fairly representative of the suburban area where the TNJ-strike-affected commuters resided. In choosing the survey locations, socioeconomic characteristics and transportation availabilities were considered in particular. This is similar to taking a stratified sample when the frequency of a desired characteristic (finding permanent "switchers" from TNJ) is low.

Four main types of transportation availabilities were established for the New Jersey commuter area. Elements of these were various combinations and levels of service by the commuter train and bus services. The car was considered to be ubiquitous. (See Figure 2 for area categories.)

TRANSPORTATION CLASSIFICATION SCHEME FOR SURVEY AREAS

Location Category	Available Transportation for Commuting			
	TNJ	Railroad Service Very Good	Fair	Other Bus
A	×	×		×
B	×		×	×
C	×	×		
D	×			×

note: blank spaces indicate lack of service

FIGURE 2

In addition, each of the selected "neighborhoods" had to meet the following criteria:

- It had to be along one of the heavily traveled routes of TNJ before the strike.
- The TNJ route had to terminate in Manhattan.
- The population of the area had to be mostly oriented to commuting to Manhattan, rather than work in New Jersey.
- All transit modes from an area were to have similar travel times into Manhattan—including all expected transfers.
- Total transit costs were to be similar on each mode.
- All available transit services within an area were to be similarly accessible.

Financial and time limitations allowed ten thousand questionnaires to be mailed out. The actual format of the questionnaire was a simple folded sheet. To return the completed form, the respondent had to fold it reversely, which allowed him free postage through the pre-paid "Business Reply Mail" format.

Addresses of households were obtained through "reverse telephone books." These contained listings grouped according to street location. Only one commuter per household was asked to respond to the survey.[2]

Not all areas received the same amount of questionnaires for the reason that varying numbers of households per area met the necessary criteria stated above.

To combat the so called "post-strike grudge phenomenon" that is commonly evident among commuters denied transportation in such a manner, the questionnaires were mailed out well after the settlement of the strike. This procedure not only allowed the hapless TNJ riders to come back to their former transportation after some initial hesitation, but it gave the deprived pre-strike TNJ riders enough time to use up the commuter discounts they may have purchased during the strike from some other commuter transit service. On the other hand, the late distribution of the survey may have introduced certain "memory effects" on the responses.

SURVEY ANALYSIS

Survey Return: The overall rate of return was 21.2 percent. The percentage can be attributed to several factors. For example, the survey distribution occurred during the height of the summer vaca-

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†Footnote numbers in parenthesis indicate references which may be found at the conclusion of this article.

tion season. In addition, since TNJ had already resumed services, the questionnaire may not have appeared to play a constructive problem-oriented role in the minds of the commuters. The returns, nevertheless, did provide an adequate data base for analyzing some of the attributes of commuter modal choice behavior during and after the strike.[3]

The survey of selected areas was aimed to produce biased returns in the sense that more TNJ bus riders were sought in proportion to the total response group than it would have been possible to find with a totally random approach. Maybe the best indication of the success of this attempt is outlined in Figure 3. Modal choices for peak

MODAL CHOICE OF A.M. PEAK PERIOD MANHATTAN BOUND COMMUTERS

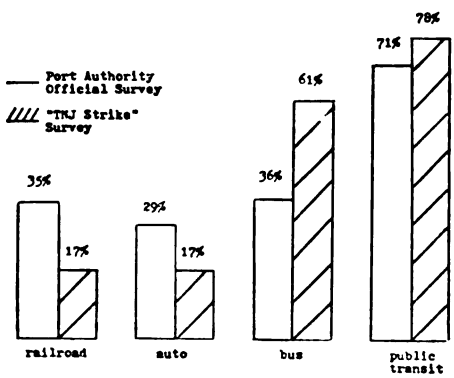

FIGURE 3

period commuters (A.M.) were compared between the figures of the survey and the tabulations of the Port Authority. It can be readily seen that the delineations in modal use are strikingly different. The most important difference, for the survey's purposes, is the fact that apparently more bus passengers were reached than would have been expected via the usual random surveying methods. (3, 4, 5, 6)

It was decided to limit the analysis to only Trans-Hudson commuters, since the destinations within New Jersey were so spread out that no adequate frequencies could be established for any location that would produce valid input for statistical purposes.

While the survey inquired about all the modes used within a particular journey to work, it was soon realized that each main mode of travel had associated with it a certain fixed secondary mode(s) with only very few exceptions. Therefore, the survey analysis concentrated on the main modes, in view of the fact that the total composition of the commuter trip could be deduced from them.

In-Strike Behavior: During the strike, all modes experienced considerable increases in usage by accommodating the diverted TNJ riders. The distribution of this extra ridership is shown in Figure 4. It is evident that the "other bus companies," i.e., the one not on strike, had the most success in attracting the abandoned TNJ users. Sample ridership of the "other bus" mode increased by 188 percent. Car-pooling fared the second highest in this respect. Railroad increases fell behind, but it is important to observe that the smallest increase occurred in auto usage—37 percent.

Expected In-Strike Behavior: Since the TNJ rider group came from the same population base as the groups using all the other modes, it was assumed that the modal choice of the diverted TNJ riders during the strike, would be similar to that of the distribution of ridership among the non-TNJ modes before the strike.[4] Therefore the pre-strike TNJ user group was proportionately projected over (added to) the various non-TNJ groups—thus yielding estimated or "expected" mode choice distributions. The actual and "expected" mode choice data is presented in Figure 5.

The X^2 (Chi-Square) Test: The X^2 test was implemented for most of the statistical analysis of the attained data. The purpose of this analytical method is to determine whether observed frequencies of various events differ significantly from expected or theoretical frequencies of events. (7, 8, 9)

In this case, the various events are the different modes of travel. The frequencies denote their respective levels of usage. The actual frequencies are drawn from the results of the survey, while the theoretical frequencies were computed

IN-STRIKE MODAL USE INCREASES

Mode	Pre-Strike Use	In-Strike Use	% Increase
Other Bus	146	421	188.4
Car-Pool	49	87	77.6
Railroad	161	261	62.1
Car	155	212	36.8
TNJ	480	—	—

FIGURE 4

DIVERGENCE BETWEEN EXPECTED AND ACTUAL IN-STRIKE MODE CHOICE

Mode	Expected	Actual	X^2 Value
Other Bus	283	421	94.18*
Car-Pool	95	87	.74
Railroad	312	261	12.16*
Car	301	212	37.78*
Other	0	10	—
Total	991	991	

*Significant X^2 values at .05 level.

FIGURE 5

according to the scheme described previously.

Since the validity of the results of the X^2 test is doubtful if any cell frequency is less than five, some aggregation of the data was necessary. These consolidations were performed with data from those survey locations where transportation alternatives were similar.

The X^2 values attained by comparing actual and expected modal choice are shown in Figure 5. For the purposes of this study, the rejection level for statistical significance was established at the .95 percentile.[5]

The purpose of this analysis was to see whether the modal choices of the diverted TNJ riders were consistent with the distribution of mode choice among the non-TNJ riders. Figure 5 indicates significant differences in "other bus," car and railroad usage. Car-pooling fell within the "expected" range.

The X^2 differences in Figure 5 can be attributed to a much higher than expected level of "other bus" usage, much less than expected auto usage and less than expected railroad usage.

Figure 6 analyzes expected and actual in-strike mode choices by the various location categories. The general finding of these calculations is that in locations with more alternative transportation services ("A" and "B" locations), higher significant differences occur between expected and actual mode choice figures than in areas with fewer alternative transit services ("C" and "D" locations).

DIVERGENCE BETWEEN EXPECTED AND ACTUAL IN-STRIKE MODE CHOICE BY LOCATION CATEGORIES

	Location Category			
Mode	A	B	C	D
Other Bus	362.34*	86.15*	—[1]	8.26*
Car-Pool	.62	5.78*	—	1.24
Railroad	66.27*	11.88*	.35	—
Car	11.91*	20.21*	.10	5.39*

*Significant X^2 values at .05 level
1 Insufficient sample size.

FIGURE 6

In a separate analysis (see Figure 7), the modal choice behavior of the diverted TNJ commuters was directly compared to that of the choices of the regularly non-TNJ commuters. The results of this investigation have provided answers rather similar to the conclusions of the previous tests. It was again realized that the in-strike modal choice of the pre-strike TNJ population was statistically different from that of the non-TNJ group.

Post-Strike Behavior: An important element of this research was the investigation of the possible long-term mode choice changes. The serious post-strike losses in TNJ's ridership implied that a certain portion of its pre-strike users decided to remain riding or using their newly-found in-strike modes. The real measure of public preference for a certain commuting mode is better reflected by these post-strike events than by the interim in-strike mode choices. While in-strike modal use changes are indicators of the capabilities of competing modes to fill the gap created by the missing TNJ services, the changes do not accurately portray the public's definite preference for these modes. The post-strike permanent diversions, however, are indications of success in permanently "capturing" new users.

Figure 8 reflects the actual levels of modal usage for the three time periods.

Previously, analysis was performed on comparing "expected" and actual in-strike mode choice. In this part of the

DIVERGENCE IN IN-STRIKE MODE CHOICE OF PRE-STRIKE TNJ AND NON-TNJ COMMUTERS

In-Strike Mode	Pre-Strike TNJ	Pre-Strike Non-TNJ	X^2
Other Bus	274	147	229.38*
Car	54	158	206.63*
Car-Pool	38	49	7.32*
Railroad	98	163	43.50*
			123.36*[1]

*Significant X^2 values.
1 Comprehensive X^2.

FIGURE 7

CHANGES IN THE MODAL CHOICE OF MANHATTAN BOUND COMMUTERS (all points)

Period	TNJ Bus	Other Bus	Railroad	Car	Car Pool	Total
Pre-Strike	480	146	161	155	49	991
In-Strike	—	421	261	212	87	981
Post-Strike	413	170	189	164	55	991

FIGURE 8

study the analysis will implement the same statistical method for comparison, but two actual modal usage levels will be used for input. The comparison, in this case, will be among pre-strike and post-strike mode choices.

Figure 9 reflects the X^2 values attained by comparing pre-strike and post-strike mode choice by separate survey area categories and for all areas. Most importantly, the TNJ comparisons indicate the highest degree of change. This information statistically proves the hypothesis that TNJ ridership has sig-

COMPARISON OF PRE-STRIKE AND POST-STRIKE MODE CHOICE BY AREAS

Location Class	Mode	Pre-Strike	Post-Strike	X^2
A	TNJ	203	180	6.27*
	Other Bus	10	16	3.70
	Car	34	37	.28
	Car-pool	7	7	0.00
	Railroad	93	107	3.22
	Total	347	347	3.87
B	TNJ	199	178	7.58*
	Other Bus	25	31	1.58
	Car	30	34	.59
	Car-pool	15	20	1.75
	Railroad	12	18	3.13
	Total	281	281	3.68
C	TNJ	27	17	5.51*
	Other Bus	1	2	—
	Car	7	8	.15
	Car-pool	0	0	0.00
	Railroad	47	55	3.18
	Total	82	82	2.96
D	TNJ	43	32	2.81
	Other Bus	74	84	2.03
	Car	75	75	0.00
	Car-pool	27	28	.03
	Railroad	0	0	—
	Total	219	219	2.26
All Areas	TNJ	480	413	18.13*
	Other Bus	146	170	4.62*
	Car	155	164	.61*
	Car-pool	49	55	.76
	Railroad	161	189	5.80
	Total	991	991	9.66*

*Significant X^2 values.
note: X^2 values for individual modes (df = 1) show significant difference if $X^2_{95} = 3.84$. "Totals": (df = 4), $X^2_{95} = 9.48$

FIGURE 9

nificantly changed (i.e. dropped) due to the strike of its drivers. The change is true for all the individual survey area categories as well as for the total situation.

On the other hand, increases in the use of other modes are only significant when all areas are examined together. In particular, there has been an overall increase in railroad and "other bus" usage. The comprehensive effect of the strike can be inferred from the X^2 value of 9.66 in the "Total" row for "All" locations.

TNJ "Switchers": Considerable research time was devoted to those people who did not return to using TNJ buses after the strike. This subgroup of the riding population was isolated from the data base. They were then analyzed in several respects.

The most pressing matter was to establish the rate of switching that had occurred. Altogether, there were 934 individuals on whom mode choice information was fully available for all three strike-related periods. Of this number, 472 (50.4%) were pre-strike TNJ commuters. After the strike, 64 (13.5%) of these riders chose to keep taking their newly-found non-TNJ mode to work. All switchers continued to use the mode which they had adopted during the work dispute.

Figure 10 shows the rate of switching by area categories. Apparently, the rate of switching from TNJ is different among AB and CD locations. A and B areas indicate a switching rate near 11%, while C and D locations produce an approximate mean of 31%. It should also be observed that the rate of TNJ usage before the strike was much higher for A and B locations than for C and D areas. The above trends lead to the hypothesis that the pre-strike levels of TNJ usage may have some bearing on the post-strike switching patterns.[6]

Of course the above statement can be mitigated by the realization that where there had been more substantial TNJ usage there was also better service by TNJ in comparison to the other locations. For this reason, the post-strike period may have produced fewer switchers in the A and B areas.

The TNJ switcher group was also analyzed regarding their choices for a new mode of transportation. The aim of this aspect of the study was to test whether the TNJ switchers, as a group, were a special subgroup of commuters—significantly differing in mode choice patterns. The modal choices of TNJ switchers were compared to two other groups, and were tested for any significant difference.

The first test compared the switchers to the total TNJ group during the strike. This test served to investigate whether the switcher population had similar non-TNJ mode choices to those of the entire TNJ population.

The results in Figure 11 indicate that the switchers were **atypical**, in non-TNJ mode choice, of the TNJ group. The switcher group is shown to be significantly different in levels of railroad and "other bus" use. The switchers are more railroad-oriented, and less in favor of riding non-TNJ buses. Regarding car and car-pool usage, the switcher group is similar to the entire TNJ group. On the whole, the difference in non-TNJ mode choice between TNJ switchers and non-switchers is highly significant.

The other comparison was between the mode choice of switchers and those commuters who had not used TNJ during any of the three strike-related time periods (see Figure 12). Since post-strike ridership figures were used for this analysis, the number of TNJ switchers first had to be deducted from the usage levels of non-TNJ modes. In this analysis the percentages and the non-significant X^2 values indicate that the mode choice alignment of the TNJ switcher group is similar to the non-TNJ group. (The only dissimilarity occurred with car use)

In conclusion, it can be deduced that the TNJ switchers were more similar in mode choice pattern to the population they switched to than to the population they switched from.

RATE OF SWITCHING FROM USING TRANSPORT OF NEW JERSEY BUSES

Location Class	X Pre-Strike All Modes	Y Pre-Strike TNJ	%(Y/X)	Z TNJ Switchers	%(Z/Y)
A	348	203	58.33	23	11.33
B	282	199	70.56	21	10.55
C	84	27	32.14	10	37.03
D	220	43	19.54	11	25.58
Total	934	472	50.40	65	13.55

FIGURE 10

COMPARISON OF IN-STRIKE MODAL CHOICES OF TNJ SWITCHERS AND NON-SWITCHERS

In-Strike Mode	TNJ Switchers	%	TNJ Non-Switchers	%	X^2
Other Bus	20	31.25	254	63.50	26.42*
Railroad	26	40.62	72	18.00	12.61*
Car	12	18.75	42	10.50	2.67
Car-pool	6	9.37	32	8.00	.13
Total	64	100.00	400	100.00	

*Significant X^2 values

FIGURE 11

At this point, we can recall that during the strike, the "other bus companies" showed the greatest increase in ridership. The permanent diversions, though, indicated by the switchers, seem to indicate that the railroads were more successful in "capturing" more switchers than any other mode.

SUMMARY

The major aim of this survey—to gain some information on the modal shift behavior of strike-affected commuters—was fulfilled. A questionnaire, distributed through the mail, was designed to reach those population areas which were to be representative of the areas served by TNJ Bus Co. The areas were selected to represent major categories of alternative transit availabilities in the Northern New Jersey suburbs adjacent to New York City.

The survey was highly experimental in the sense that it attempted to gain information on modal shifts without resorting to operating statistics. The user-oriented survey sought to find out the patterns of in-strike modal use, and the levels of permanent modal diversions.

The results indicate that during the strike, the transit services gap left open by TNJ was filled most readily by competing (non-TNJ) buses. It was also shown that the use of the automobile seems to have been the least popular choice for diverted TNJ riders.[7] The actual mode choice, during the strike, was very different from the experimental "expected" behavior. More car usage and less "other bus" ridership was expected. Car-pooling was along expected levels.

Different location categories were shown to produce various levels of agreement between expected and actual mode choice. Locations with more and/or better transit services deviated more from the expected. Of course this can be explained by the fact that where there are more opportunities for choice in transportation, prediction of usage is also more difficult.

In another analysis, it was shown that the in-strike modal choice of pre-strike TNJ riders was very different in pattern from the choices of those commuters who had not used TNJ. This can be explained by realizing that a deprived bus-travel-oriented population would be most likely to use the competing bus lines if available.

The comparison of mode choices between the pre-strike and post-strike periods indicated a significant drop in TNJ usage. The areas with better transit services produced fewer switchers from TNJ. This was also true for areas where pre-strike TNJ service was very good. Only marginally significant increases were recorded for railroad and "other bus" modes.

In contrast to the initial modal shifts (in-strike) the permanent switching was more railroad-oriented than "other bus." There were very little permanent diver-

COMPARISON OF MODAL CHOICES OF TNJ SWITCHERS AND NON-TNJ COMMUTERS

Mode	TNJ Switchers	%	Non-TNJ Commuters	%	X^2
Other Bus	20	31.85	113	24.67	1.13
Railroad	26	40.62	154	33.62	1.15
Car	12	18.75	142	31.00	5.32*
Car-Pool	6	9.37	49	10.69	.11
Total	64	100.00	458	100.00	

*Significant X^2 values

FIGURE 12

sion to the car and car-pool modes of commuting.

The post-strike switchers from TNJ were found to behave atypically of the general TNJ population in mode choice during the strike. The permanent switchers' choices resembled the patterns of the non-TNJ population.

FOOTNOTES

1 The views expressed in this paper do not necessarily reflect the positions of the Port Authority or of any other organization with which the author is or has been affiliated.

2 It was assumed that members of the same household would, by and large, have responded to the strike in a similar fashion. In view of this, the limited number of questionnaires per area was distributed to as many households—rather than as many people—as possible, in order to obtain a greater diversity of response.

3 It should be emphasized, at this point, that the assembled data base was miniscule in proportion to the population of the strike-affected area. The modal shift tendencies displayed by the following analyses do not necessarily reflect the overall behavior of the Region. On the other hand, this small data base did provide some information as to the basic commuter reaction to the strike—something that has not been previously examined.

4 Distribution was expected to be similar as far as transit modes only.

5 For example, for X^2 calculations with one degree of freedom the rejection level is established at 3.84. Computed X^2 values greater than this value, in this analysis, mean that the difference between observed and expected frequencies could have occurred by chance less than five times in a hundred.

6 Actually, the TNJ Switcher sample is very small for deducing any area-wide trends. The switching percentages are of a value when used in comparison with the estimates of the TNJ Bus Co. and the Port Authority regarding reduction in TNJ usage.

7 The lower than expected auto usage could be explained by factors such as car ownership, expected travel time, parking costs, etc.

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