Effect of 49th-50th Street Bus and Taxiway on Traffic Congestion in Manhattan

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In March 1986, the New York City Department of Transportation simultaneously imposed a series of traffic regulations along 49th and 50th streets that became known as the 49th and 50th Street Bus and Taxiway. The regulations included a curbside priority lane for buses and occupied taxis, a ban on curbside pickup and delivery during selected midday hours, and a required turn for all nonpriority vehicles at the end of each block. Because the "before" data are limited, a before-and-after experimental design was conducted for priority vehicles (i.e., buses and occupied taxis) only. The findings of a study to assess the impact of these regulations suggest that measures other than curbside loading and unloading restrictions may be more effective in providing priority for selected road users. This conclusion is tempered by the unprecedented combination of tactics that were simultaneously implemented at the site and the ensuing uncertainties in discerning the causes for the observed changes in travel time.

During the middle and late 1980s, urban traffic congestion increased. This increase led to outcries from decision makers and the public at large. Although many tactics have been proposed and implemented, a group targeted frequently for travel restrictions is those involved in the movement of urban goods, in spite of a recent literature review (*1*) that revealed limited empirical assessments of traffic benefits due to truck restrictions. Further, the same review revealed that little is known of the economic consequences of goods movement restrictions on transportation providers, shippers, or customers.

It is legitimate to ask how this state of affairs has evolved. A simplistic response is that people vote and packages do not. Beyond this rationale, it must be assumed that many transportation professionals believe that restricting the delivery of urban goods and services by light trucks and vans is a positive policy option in relieving congestion. The congestion-related effects of a particular restriction on delivery of goods and services formed the focus of this research.

In March 1986, the New York City Department of Transportation (NYCDOT) implemented a series of traffic regulations on 49th and 50th streets, a pair of one-way streets in Manhattan, between 3rd and 8th avenues (Figure 1). These regulations, referred to by NYCDOT as the 49th and 50th Street Bus and Taxiway, are listed below:

- A red zone priority lane was implemented in the right-side curb lane for the exclusive use of buses and loaded taxis.
- Private vehicles and unloaded taxis could use 49th and 50th streets but were required to turn off after traveling one block (shown in Figure 1 as dashed lines at each intersection).
- On-street loading and unloading of vehicles were prohibited on 49th Street from 11:00 a.m. to 2:00 p.m. and on 50th Street from 2:00 to 5:00 p.m., Monday through Friday.

The first two sets of regulations were in effect from 8:00 a.m. to 6:00 p.m., Monday through Friday.

These regulations had a significant effect on traffic patterns on both 49th and 50th streets, as well as on the neighboring streets and avenues. A particular concern was that three traffic control measures were implemented simultaneously: a priority lane, mandatory turns for classes of vehicles, and restrictions on loading and unloading. In evaluating the effectiveness of the bus and taxiway, it is important to understand how each individual regulation affected traffic flows.

Because of a concern for the continued viability of their businesses, a number of companies joined together to form the Business Committee on Midtown Traffic. This organization requested that the Northwestern University Transportation Center submit a proposal for a study that would assess the impacts of the bus and taxiway. The accepted proposal had two major components: (a) a study of traffic impacts and (b) a study of companies' perceptions of how the restrictions affected their operations in the area. This paper reports findings of the traffic impact phase of the research.

OBJECTIVES OF THE RESEARCH

The objectives of the traffic study were

1. To measure the effect of the 49th and 50th street regulations on travel time in the corridor. This included separate measurement of travel time along 49th and 50th streets as well as the nearest adjacent streets, 48th and 51st. Particular emphasis was placed on identifying spatial and temporal changes in travel time. When possible, the magnitude and cause of any changes were determined.
2. To separately estimate the effect of restrictions on loading and unloading along 49th and 50th streets. Because these restrictions were imposed simultaneously with mandatory turns for through traffic, it was important to separate their effects.

The overall intent of the research was to conduct an independent assessment of the effect of the traffic regulations. In developing a study design, emphasis was placed on the ability to statistically test hypotheses concerning these effects.

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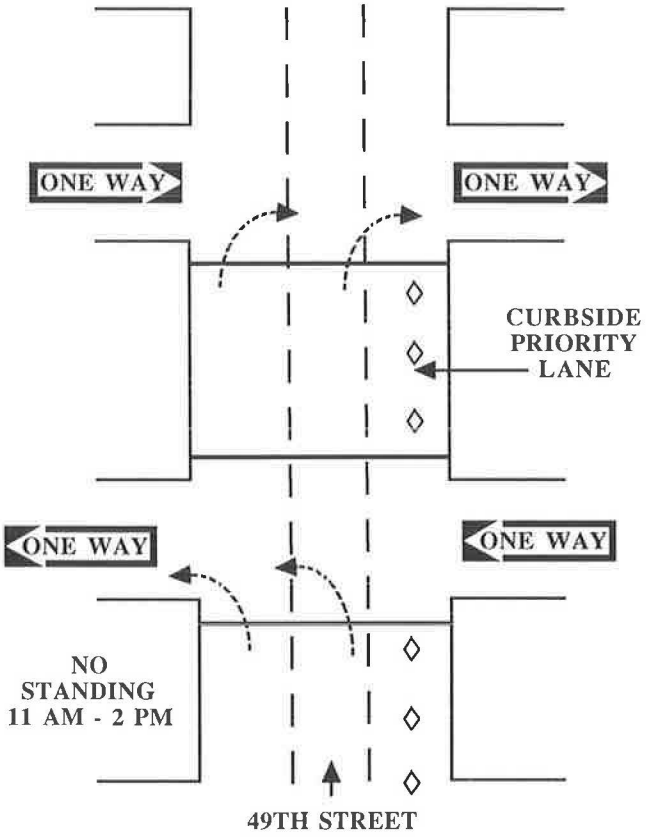

FIGURE 1 Diagram of corridor traffic regulations.

STRUCTURE OF THE ANALYSIS

Although data describing conditions after implementation of the bus and taxiway could be collected easily, the research team had to rely on NYCDOT to provide data describing previous conditions. (Contact was not established between the Business Committee and Northwestern until after the bus and taxiway was implemented.) Preliminary meetings with NYCDOT representatives revealed that travel time data were periodically collected on selected New York City streets during spring and fall. NYCDOT committed to providing available travel time data for affected streets before bus and taxiway implementation. Because limited flow data were available for that period, travel time (or speed) was chosen as the primary measure of effectiveness. A subsequent report by NYCDOT (*2*) indicated that total volumes on 49th and 50th streets had remained nearly the same, although the mix of vehicles had changed dramatically: There were many more taxis and fewer trucks and private automobiles. A before-and-after design was thus undertaken using travel time as the primary measure of effectiveness.

The research team asked NYCDOT to provide copies of individual travel time runs in the study corridor. Summary data containing the means of several runs were initially sent to the researchers, but these were insufficient for statistical inference. After several months of discussion, individual travel time runs were provided to the research team for 49th, 50th, and 51st streets for fall 1985. At this point, the research team had a choice:

1. Conduct limited analyses of summary data provided by NYCDOT (which would consist of comparing two numbers without the ability to statistically test hypotheses unless a variance and sample size were assumed) or
2. Use the more limited set of raw data for fall 1985, but conduct valid statistical tests of hypotheses concerning equality of mean travel times before and after the bus and taxiway was implemented.

As part of these deliberations, Figure 2 was constructed from NYCDOT Speed Books (*3*, *4*), which are a compilation of mean travel times on selected routes for a season and year. The plots indicate that the fall 1985 travel times for 49th and 50th streets were a little higher than previous times. The research team concluded that it was reasonable to use fall 1985 travel times to characterize traffic conditions before the bus and taxiway. Because the fall 1985 travel times were somewhat higher, the decision might have created a bias in the direction of overstated bus and taxiway time savings. Therefore, a *t*-test was used to test the null hypothesis of equal mean travel times for unequal sample sizes and unequal (and unknown) variances. The alternative hypothesis was that the means were unequal.

The analyses of the travel times were complicated by the overlapping of the traffic restrictions. One figure of merit that could have been used was the change in average travel time from 3rd to 8th avenues during the entire day. This measure is useful in determining average efficiency for crosstown travel, but it ignores important differences in the spatial and temporal patterns of corridor use. For example, it is useful to know the changes in travel time for the hours just before the restrictions on loading and unloading, the hours during the restrictions, and those after the restrictions.

The spatial differences are particularly important because of the mandatory turns. After the bus and taxiway was implemented, many vehicles had to approach their destination along the nearest avenue and then turn directly along 49th or 50th street for less than a block. If the destination was along a block that had experienced an increase in travel time, that user would experience an increase in travel time, not a reduction. After serving a customer on one block, a vehicle may have needed to serve another customer on the next block of 49th or 50th Street. An eight-block detour was typically needed in this situation because of the mandatory turns and the one-way grid street pattern. Separate analyses were therefore conducted of block-by-block changes, identifying road sections that experienced travel time increases or no significant changes as well as those that experienced travel time reductions.

DATA COLLECTION

Overview

NYCDOT collected travel time data using department vehicles during fall 1985. These were the only New York City data used in the analysis. Inspection of the completed data forms indicated that the city used a technique similar to one in the *Transportation and Traffic Engineering Handbook* (*5*). Unfortunately, data were only provided for through vehicles on 49th, 50th, and 51st streets; no analysis of 48th Street

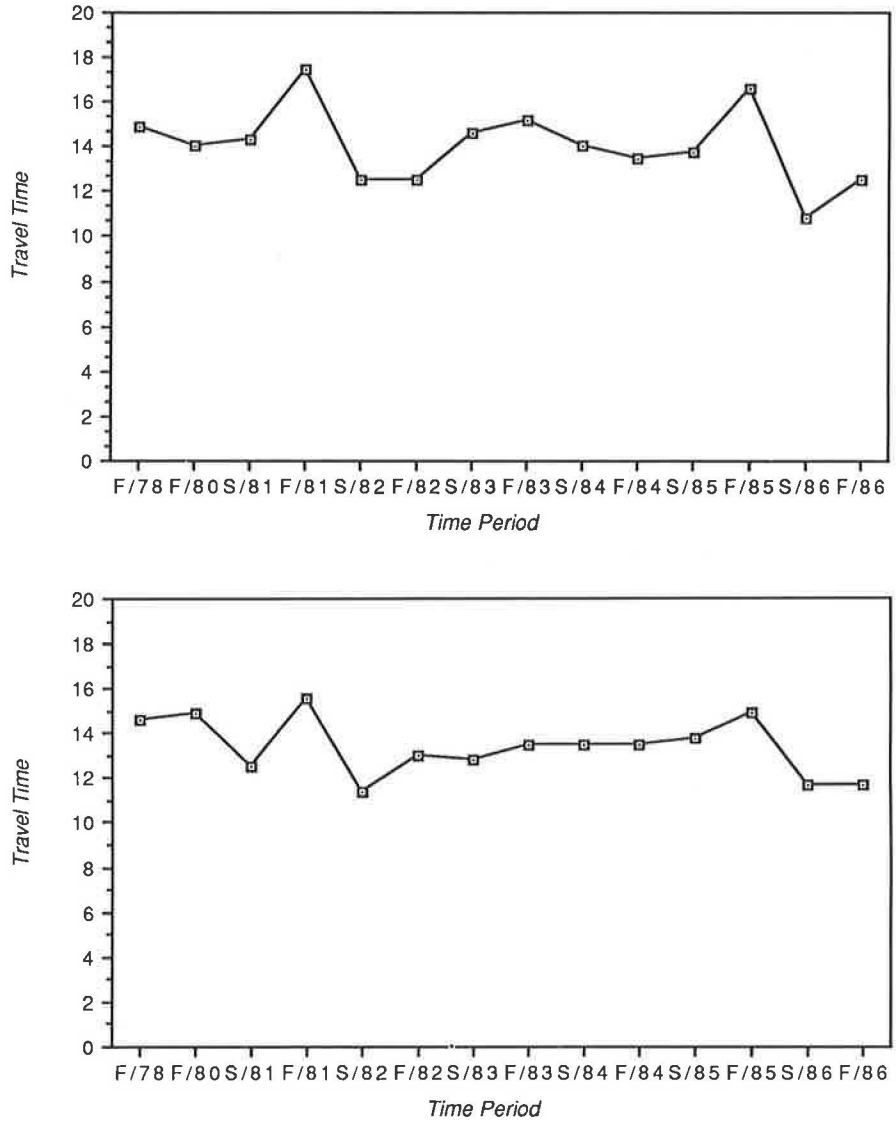

FIGURE 2 Historical travel times: (*top*) 49th Street and (*bottom*) 50th Street.

was possible nor was it possible to assess travel time changes for travelers turning off the subject streets because of the mandatory turns.

Travel times after implementation of the bus and taxiway were collected by the research team. Several visits were made to Manhattan during late summer 1986 to plan and design the data collection activity. Data were collected on Tuesday and Thursday from September 30 through October 9 between 8:00 a.m. and 6:00 p.m. The streets studied were 48th through 51st between 3rd and 8th avenues. Because of the vehicular restrictions on 49th and 50th streets, Medallion taxis with New York cab drivers were used as the data collection vehicles.

Travel time and stopped delay data were collected using the "moving vehicle" method (*5*). There were two observers in the data collection vehicles. One recorded the elapsed time between each intersection and the other, the duration of the delays and their causes. The drivers of the vehicles had no role in observing and collecting data. They were specifically asked to drive as they normally would so the data would reflect actual taxi travel times in the corridor. Thus, travel times are reflective of priority vehicle travel in the corridor. Nonpriority vehicles experienced much longer travel times.

In addition to the usual data collected in such a study, additional data were collected to discern the effect of the curb use restrictions on travel time. One observer recorded the number of vehicles illegally parked at the curb during the restricted hours and their location along the block. Parked vehicle travel times were compared with the travel time data collected when no vehicles were parked at the curb during the same period. These data were used as part of a field simulation to provide a more detailed assessment of the effect of the restrictions on loading and unloading.

Comment on Travel Time Estimates

Travel times in an urban street corridor are affected by a wide variety of factors. Driver perceptions of the value of time can be conceptualized to be balanced against operating costs and safety level; an outcome is the driver's desired travel time or

speed. The presence of other traffic and pedestrians because of urban economic activity may cause congestion or accident risk, further constraining this travel time choice. As each of these factors changes (as they did in the bus and taxiway), travel times change.

This conceptualization makes it easier to see how each factor was considered during the data collection study design. In concept, direct measurement of the effect of the three road traffic controls implemented on 49th and 50th streets, the exclusive lane for buses and taxis, the restrictions on loading and unloading during midday, and the mandatory turns at each intersection for all vehicles other than buses and loaded taxis would be desirable. The level of enforcement necessary to ensure compliance with the restrictions is implicitly included in the assessment. During visits to the site, it appeared that enforcement at the intersections was fairly strict; traffic agents were typically posted at each intersection. Enforcement of the restrictions on loading and unloading was more erratic, as shown by the illegal curb use. Thus, the travel time measurements captured the collective effect of changes in lane use (the bus lane), parking (loading and unloading restrictions), turns, and enforcement.

It was assumed that several factors would not change significantly in the 1-year time period between the before-and-after studies. These included the driver's value of time and the perception of fuel, insurance, and vehicle maintenance costs. The road design itself did not change in the corridor during the year nor did the handling and braking characteristics of the vehicles. It was assumed that the level of other street use (e.g., for construction) had not appreciably changed during the year. Given the intense level of building and restoration activity in Manhattan, this did not seem an unreasonable assumption. It was also unlikely that signal timing changes were implemented because of the dense grid that characterizes the Manhattan street system and the current lack of central computer control in Manhattan.

Because the data collection and analysis were constructed to compare data from two consecutive fall seasons, there were controls for fluctuations in traffic (pedestrian and vehicular) that were due to seasonal economic cycles. Implicitly, there were also controls for broad patterns in weather and hours of daylight and darkness. By waiting until fall 1986 to collect the data, users were allowed over 6 months to change their operations in response to the bus and taxiway. The travel times thus reflected what was believed to be a new equilibrium pattern of operations in response to the traffic restrictions. This experimental structure allows the use of a variety of statistical procedures to test whether differences in travel times were due to chance or whether they were lasting effects. Further details of the data analysis and summaries of raw data are contained in the technical report of the study (*6*).

These estimates of changes in travel time did not include the time wasted by any vehicle other than a loaded taxi or bus that tried to move more than one block along 49th or 50th Street. Any nonpriority vehicle that attempted to cross an avenue was required to travel an additional eight blocks to reach the intersection entry at the next block (due to the mandatory turns and the largely one-way grid of streets). These circuitous routings had important implications for travel time and air quality that were too difficult to measure in the field. Thus, the estimates of travel time changes should be considered as a best-case scenario biased in favor of the bus and taxiway. The experiences of many users were expected to be somewhat worse.

EMPIRICAL FINDINGS OF TRAVEL TIME STUDIES

Overall Effect

For a crosstown trip along 49th Street from 3rd to 8th Avenue between 8:00 a.m. and 6:00 p.m., the average travel time savings was significant for any user. Before the restriction, the average travel time on 49th Street was 15.1 min. Afterward, travel time was 9.2, a drop of 5.9 min. On 50th Street, however, a trip from 8th to 3rd Avenue that previously took 10.1 min took 9.7 min after the restriction—a difference of only 0.4 min. After implementation of the restrictions, travel times on 51st Street increased by 22 percent, from an average of 10.1 min to an average of 12.3 min. Only the 49th and 51st street changes were statistically significant. Further, the temporal and spatial patterns indicated clear patterns of response to the 49th and 50th street restrictions.

Temporal Distribution of Travel Times

The three traffic control measures that made up the bus and taxiway were not all implemented during the same time period. The priority lane and mandatory turns were imposed on weekdays from 8:00 a.m. to 6:00 p.m. Curb use was restricted from 11:00 a.m. to 2:00 p.m. on 49th Street and from 2:00 p.m. to 5:00 p.m. on 50th Street. It was expected that the three control measures would alter usage patterns along 49th and 50th streets and result in complex patterns of travel time changes throughout the day and along streets in the area as users responded to the restrictions.

Figures 3 and 4 show travel times by hour for crosstown travel between 3rd and 8th avenues on 49th and 50th streets, respectively. Average travel times before the bus and taxiway (fall 1985) and after implementation (fall 1986) are plotted separately, and differences attributable to the bus and taxiway are highlighted with diagonal lines. The crosshatched areas represent a qualitative estimate of the travel time savings that may be attributable to the loading and unloading restrictions in effect only during these time periods on each street. The area was determined by extrapolating travel time changes at the beginning of the loading and unloading restrictions (i.e., 11:00 a.m. on 49th Street and 2:00 p.m. on 50th Street) to those existing at the end of the restrictions (after 2:00 p.m. and 5:00 p.m., respectively). The line connecting the beginning and end points can be interpreted as a trend line that represents changes that might have occurred in the absence of the loading and unloading restrictions. Sample sizes for the two data sets were quite different: "before" data (collected by NYCDOT) typically contained 2 observations per hour, whereas "after" data (collected by Northwestern) typically contained 10.

Figure 3 shows substantial travel time savings during the midday period (roughly 10:00 a.m. to 3:00 p.m.). The hour from 3:00 to 4:00 p.m. had virtually the same travel time before and after the restrictions as did the 8:00 to 9:00 a.m.

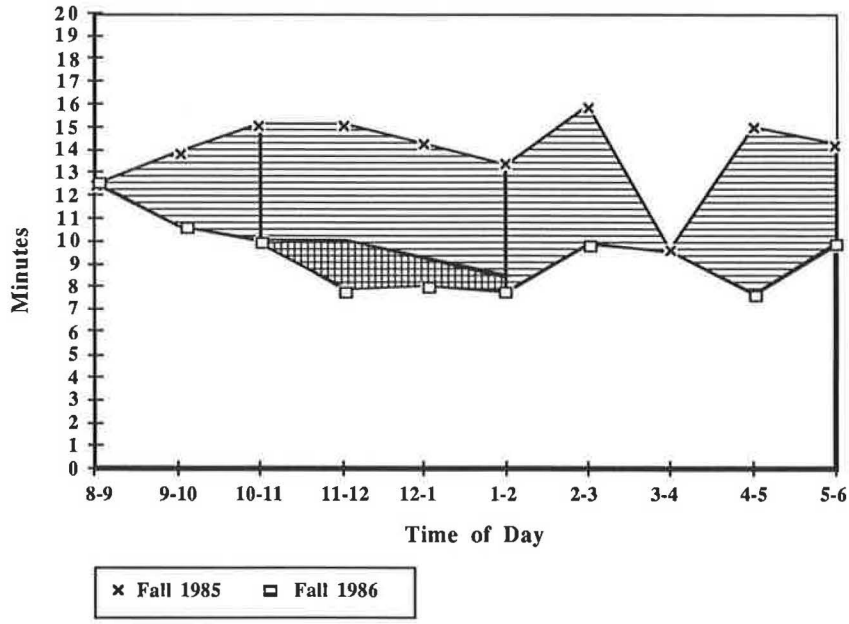

FIGURE 3 Travel time: 3rd to 8th Avenue on 49th Street.

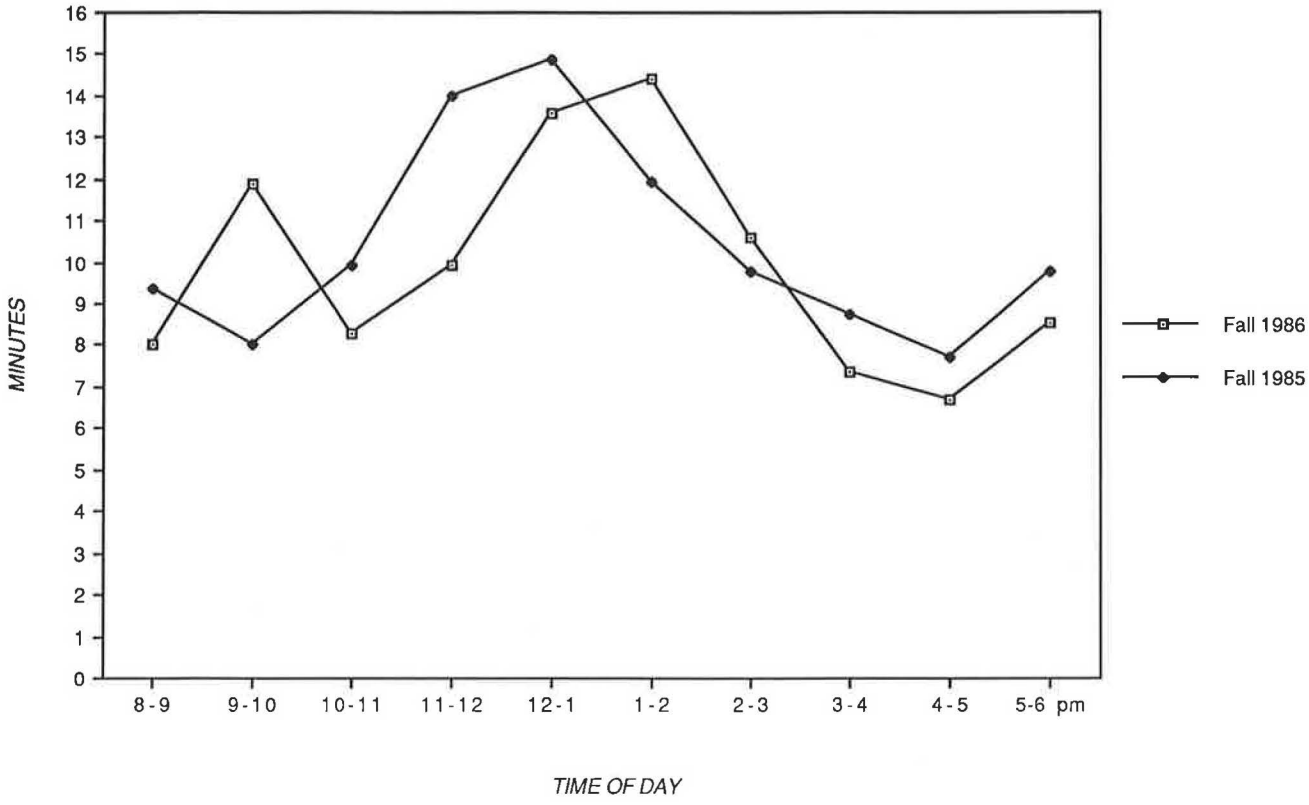

FIGURE 4 Travel time: 3rd to 8th Avenue on 50th Street.

hour. Large savings were also apparent from 4:00 to 6:00 p.m. Figure 4 shows a different set of travel time changes for 50th Street. There were major reductions in travel time from 10:00 a.m. to 1:00 p.m. and from 4:00 to 6:00 p.m. However, there were increases in travel time from 8:00 to 10:00 a.m. and from 1:00 to 3:00 p.m.

To facilitate statistical tests, the 10 hr of the restriction were divided into four time periods: 8:00 to 11:00 a.m.; 11:00 a.m. to 2:00 p.m.; 2:00 to 5:00 p.m.; and 5:00 to 6:00 p.m. These correspond to time blocks just before curb use restrictions, during 49th Street restrictions, during 50th Street restrictions, and after curb restrictions, respectively.

Statistical tests comparing mean travel times on 49th Street supported the earlier qualitative assessments (see Table 1): travel time changes from 8:00 to 11:00 a.m. were 2.5 min, the smallest of any time period. The travel time change for all time periods was also statistically significant.

Statistical tests of travel time change on 50th Street (see Table 1) revealed that there was no significant change in crosstown travel time for any of the four time periods. Although Figure 4 appears to show savings in travel time with the restrictions, the apparent differences in average travel time are overwhelmed by variations in the data. These findings are consistent with the earlier conclusion of no significant travel time change on 50th Street.

Although the pattern of travel time changes was different for the two streets, there is a common conclusion to the analysis: the major factors contributing to time savings appear to be the priority lane and mandatory turns, not the restrictions on loading and unloading.

The travel times on 51st Street, as a function of time of day, are shown in Figure 5 and Table 1. Several clear patterns emerge: travel times from 8:00 to 10:00 a.m. were much higher than before the bus and taxiway, but the result is of marginal

TABLE 1 TRAVEL TIME CHANGES BY TIME OF DAY

	Travel Times (min) by Time of Day			
Street and Time Period	8–11 a.m.	11 a.m.–2 p.m.	2–5 p.m.	5–6 p.m.
49th Street				
Before	13.3	19.2	13.7	14.3
After	10.8	7.8	9.0	9.1
Difference	2.5[a]	11.4[a]	4.7[a]	5.2[a]
50th Street				
Before	9.0	13.4	8.4	9.8
After	9.9	12.0	8.2	8.5
Difference	−0.9	1.4	0.2	1.3
51st Street				
Before	9.2	12.0	10.3	9.0
After	11.2	14.8	12.1	11.1
Difference	−2.0	−2.8[a]	−1.8[a]	−2.1

[a]Implies a statistically significant difference for $\alpha = 0.05$.

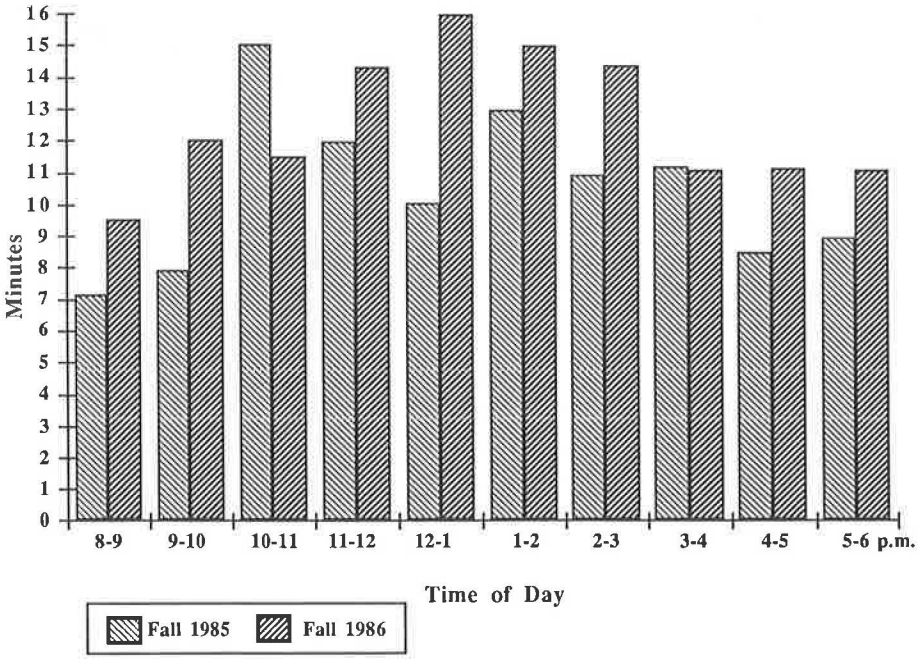

FIGURE 5 Travel time: 3rd to 8th Avenue on 51st Street.

statistical significance. These findings could have been caused by vehicles arriving early in the corridor to avoid the restrictions on 49th Street. There were also large travel time increases from 11:00 a.m. to 2:00 p.m. (when loading and unloading were banned on 49th Street) and from 2:00 to 5:00 p.m. (when 50th Street curb restrictions were initiated). The worst increase occurred from 12:00 to 1:00 p.m., when there were also high pedestrian flows in midtown. The magnitude of these differences was also substantial, with changes frequently exceeding 3 min and occasionally nearing 6 min.

Another observation should be made concerning these travel time trends. To some extent on 49th and 51st streets, but quite clearly on 50th Street, travel times tended to reach a peak during midday both before and after the restrictions. Field observations revealed that this was primarily attributable to the large number of pedestrians that circulated in the corridor and competed with high vehicle turn flows for limited roadway space. During morning and afternoon rush hours, the pedestrian conflicts lessened somewhat, easing turns for vehicles.

This pattern of congestion was quite different from that experienced in many other cities and substantially complicated the identification of causes of congestion. During field data collection, the vast amount of congestion occurred at the intersections. It was simply impossible to observe and identify what was causing the delay: poor signal timing, pedestrian conflicts, the mandatory turns, inadequate capacity, or some combination of these factors. Although it was possible to describe what had occurred, it was more difficult to provide a more detailed attribution of causality.

Spatial Distribution of Travel Times

Figures 6 and 7 show the spatial distribution of travel time changes for 49th and 50th streets, respectively, using mean times from 8:00 a.m. to 6:00 p.m. Figure 5 shows an enormous time savings (nearly 4 min) on 49th Street approaching 7th Avenue and moderate savings (typically 1 min) approaching 6th and 8th avenues. There were small changes at other intersections, including an increase approaching Lexington Avenue. Statistical tests (see Table 2) support these qualitative assessments. Significant travel time savings on 49th Street for the entire day were only observed on the west side approaching 6th, 7th, and 8th avenues. There were scattered travel time savings and increases on other mid-Manhattan and east side streets, but they were not sustained throughout the day. The massive time savings approaching 7th Avenue dominated any other travel time changes along 49th Street.

Findings for 50th Street were again quite different. Figure 7 shows travel time savings approaching Madison and 3rd avenues but increases in travel times approaching 6th and 5th avenues. Statistical tests confirmed these findings. What was gained at 3rd Avenue and Madison was lost on 5th and 6th avenues. The net result for a crosstown trip was no improvement in travel time with the restrictions. On this street, westside users were worse off because of the bus and taxiway, even if circuitous routings were not considered. Only users approaching Madison and 3rd avenues received any benefit throughout the day.

As with other streets in the bus and taxiway area, there were significant spatial patterns to the travel time changes on 51st Street (see Figure 8 and Table 2). Substantial travel time increases occurred approaching Lexington, Madison, and 7th avenues. These increases existed on the Lexington Avenue approach for all time periods except 11:00 a.m. to 2:00 p.m. There were also significant increases in travel time on the 7th Avenue approach, particularly from 11:00 a.m. to 5:00 p.m., when the loading and unloading restrictions were in effect on 49th and 50th streets.

EFFECT OF LOADING AND UNLOADING RESTRICTIONS ON TRAVEL TIME

The effect of the curb use restriction was evaluated by noting the presence of any illegally parked vehicles during the hours restricting loading and unloading. These vehicles effectively

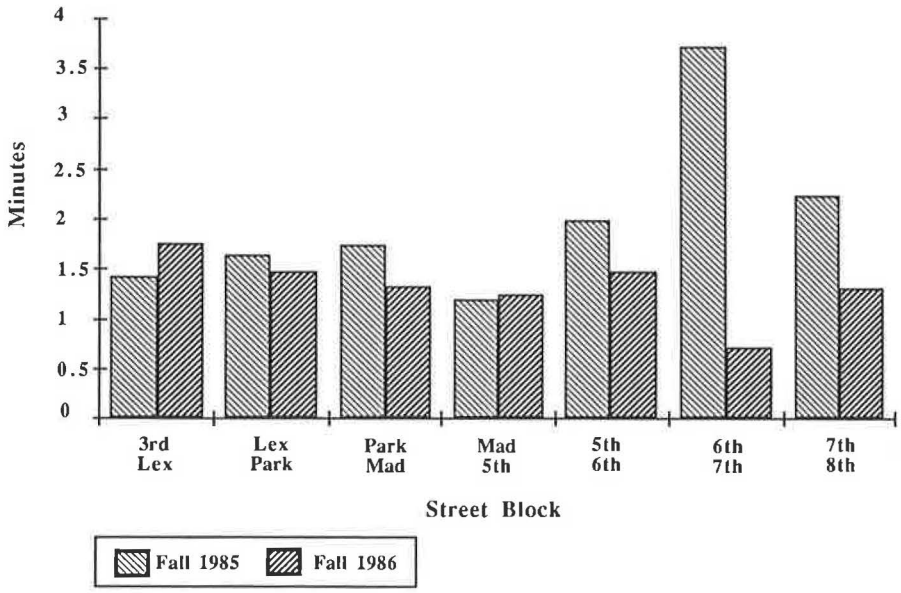

FIGURE 6 Block travel time: 9:00 a.m. to 6:00 p.m. on 49th Street.

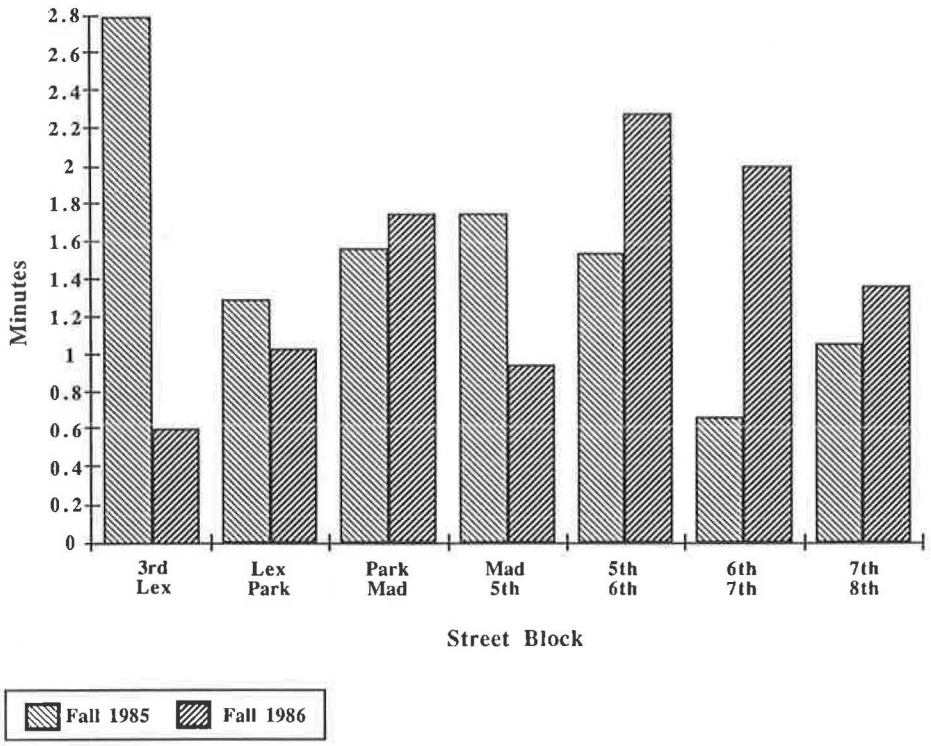

FIGURE 7 Block travel time: 8:00 a.m. to 6:00 p.m. on 50th Street.

TABLE 2 TRAVEL TIME CHANGES ALONG INDIVIDUAL BLOCKS: 8:00 A.M. TO 6:00 P.M.

	Mean Travel Times (min) by Blockface[a]						
Street and Time Period	3rd and Lexington	Lexington and Park	Park and Madison	Madison and 5th	5th and 6th	6th and 7th	7th and 8th
49th Street							
Before	1.6	1.4	1.7	1.3	2.3	4.6	2.2
After	1.7	1.4	1.3	1.2	1.5	0.7	1.3
Difference	−0.1	0.0	0.4	0.1	0.8[b]	3.9[b]	0.9[b]
50th Street							
Before	2.5	1.1	1.6	1.7	1.5	0.7	1.0
After	0.6	1.0	1.7	0.9	2.2	1.9	1.4
Difference	1.9[b]	0.1	−0.1	0.8[b]	−0.7[b]	−1.2[b]	−0.4
51st Street							
Before	1.5	1.2	1.3	1.2	2.3	1.4	1.3
After	2.3	1.4	1.7	1.3	2.1	2.2	1.2
Difference	−0.8[b]	−0.2	−0.4[b]	−0.1	0.2	−0.8[b]	0.1

[a]49th and 51st streets are one way westbound; therefore, vehicles move from 3rd Avenue toward 8th Avenue. 50th Street is one way eastbound; therefore, vehicles move from 8th Avenue toward 3rd Avenue.
[b]Significant difference in travel time for $\alpha = 0.5$.

blocked one through lane. By comparing travel times when the lane was blocked by one or more vehicles with the travel time without blockage, an estimate of the effect of the restriction was obtained. Clearly, having one vehicle illegally parked was not the same as having the lane full; however, it only took one blockage to substantially reduce the utility of the lane. Importantly, collecting data during the time of day that the restrictions were in effect controlled for the effect of pedestrian and vehicle flows directly.

In addition to the presence of the illegally parked vehicles, their location was also recorded. Vehicles parked farthest upstream on a block were recorded as in the last third of the block, vehicles in the next third as in the middle of the block. Vehicles closest to the traffic signal controlling traffic on the block under study were recorded as in the first third of the block. The hypothesis was that vehicles parked in the first third of the block had the largest effect on travel time because they directly affected queue discharges and turns. This was

an important comparison because it helped to determine how close to the intersection to allow loading and unloading if the restriction was modified.

Two separate comparisons were conducted. The first compared travel times with and without illegal standing on each blockface of 49th and 50th streets. The second attempted to determine the effect of having a vehicle in the first third of the block compared with one or more parked in the other two-thirds. Due to a limited sample size, the latter comparison could not be made for each blockface. Instead, data were aggregated from all blocks and, to correct for the effect of distance, speed rather than travel time was used.

Comparisons for Each Block

Figures 9 and 10 show the travel time comparisons for 49th and 50th streets, respectively. Although the travel times on 49th Street were generally higher when standing was observed, none of the differences was statistically significant. Travel times on the west end of 49th Street were nearly the same, irrespective of the presence of illegal curb use.

The results for 50th Street were similar to those for 49th Street: none of the blocks had significantly different travel times because of illegal curb use. Interestingly, on two blocks (Lexington and Madison), travel times were slightly higher,

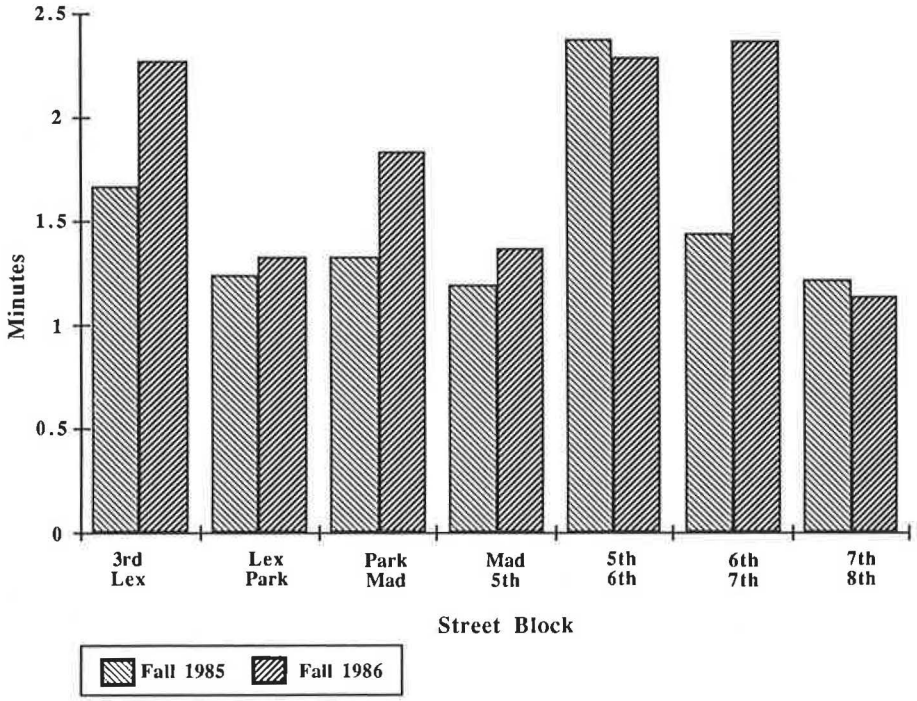

FIGURE 8 Block travel time: 8:00 a.m. to 6:00 p.m. on 51st Street.

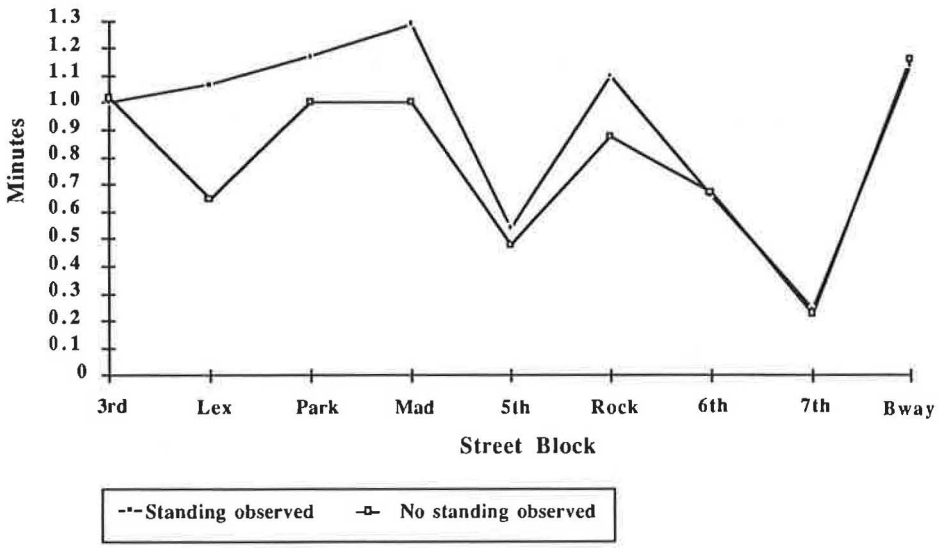

FIGURE 9 Impact of "No Standing" on travel time: 49th Street.

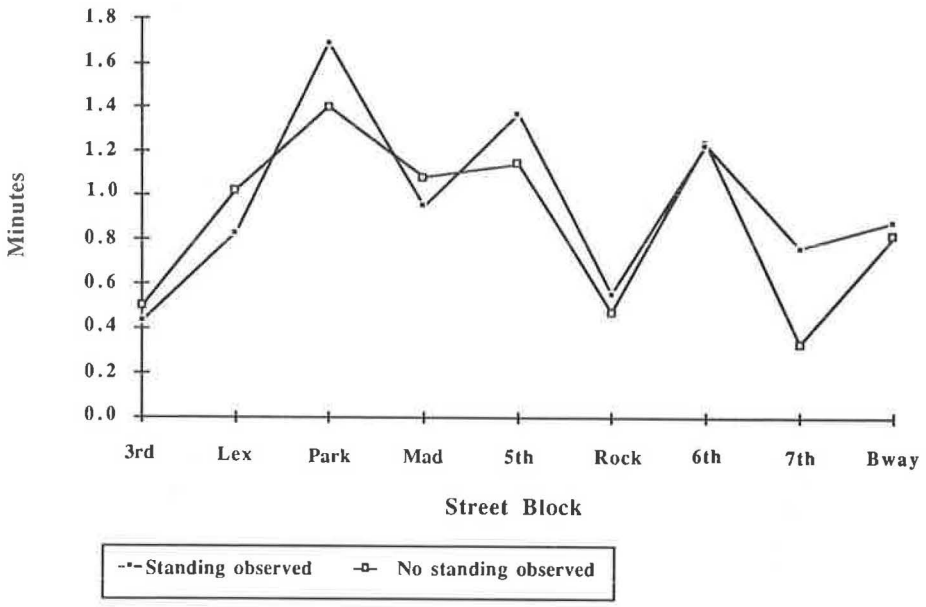

FIGURE 10 Impact of "No Standing" on travel time: 50th Street.

with no curb use. Again, none of these differences was statistically significant.

Effect of Location of Illegal Curb Use

The second set of analyses compared travel times for two conditions:

1. When vehicles were illegally parked in the first third of the block, and
2. When vehicles were illegally parked in the end, middle, or both remaining thirds of the block.

The average speed was 8.3 mph for the first case and 8.9 mph for the second case. Statistical tests found no difference between them. There appeared to be no measurable effect of allowing loading and unloading far upstream of the exit intersection. Thus, given the nature of the experiment and the importance of allowing for queueing and turns, it appeared reasonable to allow loading and unloading in the two-thirds of the block farthest from the controlling traffic signal.

Discussion of Results

These detailed comparisons largely support the conclusion of the previous section: The restrictions that had the greatest effect on travel time were the priority lane and mandatory turns. In comparison, the effect of the loading and unloading restrictions was extremely small.

It could be argued that these analyses were not valid because the effect of one truck at the curb is very different from that of a full curb. Although in principle this is true, from the perspective of the number of available approach lanes it is not. Vehicles would have to merge to pass the illegal vehicle; the merging action would slow them down enough to result in some travel time difference. However, in these data, no significant effect was evident. The volumes appeared to be low enough that the merging and weaving around illegally parked vehicles could be executed with limited delay.

Thus, for this package of restrictions, the loading and unloading regulations make little sense and should be eliminated. To allow easy access for turns, curb use prohibitions should remain for the first third of each block. Travel time data should be collected to monitor this change in the restrictions. After several months of study testing and evaluation in the field, a more definitive judgment could be made on effects of loading and unloading restrictions. Because flow data are not systematically available in the corridor, it is difficult to offer more precise guidelines to other potential users of these types of restrictions. Flows with the bus and taxiway were clearly heavy but not oversaturated. The restrictions on loading and unloading were implemented during midday, when peak commuter traffic was much less of a problem. From a traffic management perspective, the restrictions on loading and unloading appear to have had limited effect because of their midday imposition; it is this timing, however, that makes them particularly onerous to delivery and service vehicles attempting to meet customer needs in the area. For these reasons, the study concluded with recommendations for a set of field experiments that selectively remove portions of the restrictions. These recommended studies are discussed in the following section.

SUMMARY AND CONCLUSIONS

Extensive data analyses were conducted to assess the travel time impact of the 49th and 50th Street bus and taxiway in Manhattan. A before-and-after comparison was conducted using data provided by NYCDOT (to characterize conditions before the restrictions) and data collected by Northwestern University Transportation Center (to characterize conditions

afterward). Data were compared between fall 1985 and fall 1986 to control for seasonal traffic fluctuations and allow time for corridor users to respond to the restrictions.

The travel time studies yielded remarkably different results for the two streets on which the restrictions were implemented. There were significant travel time reductions on the west side of 49th Street throughout the day. Although there were scattered time savings approaching other mid-Manhattan and east-side streets, the savings were not sustained throughout the day and were balanced somewhat by increases in travel time approaching Lexington and Park avenues.

On 50th Street, traffic patterns were more complex; some blocks had time savings, whereas others experienced travel time increases. The conclusion is that crosstown travel times did not change significantly for the entire day or for specific time periods during the day, including the time when the curb use restrictions were in effect.

Attempts to isolate the effect of the loading and unloading restrictions revealed that the travel time savings, when they occurred, were overwhelmingly due to the priority lane and mandatory turns, not the curb use restrictions.

There were significant travel time increases along 51st Street, apparently because of the restrictions on 49th and 50th streets. The increases were particularly large approaching Lexington, Madison, and 7th avenues.

The analyses identified several locations that experienced no change in travel time with the bus and taxiway. Experiments with removal of the mandatory turn restrictions should be performed. These proposed changes in the turn requirements recognize the cost paid by nonpriority vehicles due to the eight-block circuitous routing. A series of experiments should be conducted in which the turn restrictions are changed to ease traffic circulation. The effect of these changes on corridor travel time can be closely monitored during the experiment so that taxi and bus travel time savings are not eroded.

This fine tuning of the taxiway system should retain savings for buses and loaded taxis while allowing some cost relief for other corridor users. Air quality is also likely to benefit from concurrent vehicle mileage reductions.

It is recommended that the restrictions on loading and unloading be removed on 49th and 50th streets except for the third of each block that is closest to the controlling traffic signal. Although it appears from the analysis that the restrictions on loading and unloading could be eliminated completely, preserving a third of the block for moving vehicles may be advisable.

Despite a rather extensive data collection effort after imposition of the bus and taxiway, it was extremely difficult to attribute delays to particular causes and even more difficult to offer specific advice about likely effects should these policies be attempted elsewhere. The process of experimental removal and monitoring of the traffic regulations along 49th and 50th streets is recommended so that the government's ability to provide priority service for selected road users can be determined by the costs imposed on nonpriority vehicles. Although other analysis techniques, such as simulation, may be attempted to estimate travel time effects, the complexity of the regulations argues for an experimental approach.

The basic question that is left unanswered is, which street, 49th or 50th, has given results that are more typical or expected? The short answer is one of uncertainty; however, the focus of travel time changes primarily along one block of 49th Street and the more varied and dispersed changes along the remainder of 49th and all of 50th Street argue for a cautious approach to implementation of this mix of tactics in other locations. If the more incremental experimental approach is adopted in Manhattan and elsewhere, more can be learned about how these regulations interact.

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