IMMEDIATE EFFECT OF MRT 3 OPERATION ON BUS SERVICE ALONG EPIFANIO DE LOS SANTOS AVENUE (EDSA), METRO MANILA

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Abstract: Operating service characteristics of buses plying the EDSA route were tested to determine whether changes have occurred after the introduction of the mass rail transit (MRT 3) system along the said road. Using hypothesis testing, there was some evidence of a decrease in the mean of the average number of passenger-kilometers carried by city buses especially during the afternoon peak period in the North-bound direction several months after the MRT 3 has been in operation. Tests also showed that there is significant improvement in the mean of the average travel and running speeds of buses during the morning peak period in the South-bound direction. Buses were able to withstand the stiff competition brought about by the MRT 3 service by introducing more non-airconditioned buses and improving service through faster travel by reducing the number of stops along EDSA, especially during the morning peak period.

Key Words: Bus transit, Mass rail transit, Public transport system, Hypothesis test, t-test

1. INTRODUCTION

Bus service operations were surveyed using the conventional method of onboard bus passenger survey before and after the MRT 3 introduced its service along EDSA. Data on bus services before the MRT 3 operation were gathered from the period January 1998 to June 2000. Post-MRT 3 data were gathered starting January 2001, barely six months since the opening of the whole stretch of the operation on July 17, 2000. Relevant data gathered include the number of alighting and boarding passengers, moving and stop times and causes of delays. Data were then processed to obtain average travel and running speeds, bus journey time composition due to traffic delays, passenger stops, and moving time as well as average passenger-kilometer performance of buses.

Hypothesis testing was the primary method used to determine changes in the service performance and operation of buses after the introduction of MRT 3 along EDSA. The assumption of independent population, normality of data and equal variance were first verified before hypothesis testing was performed.

Volume studies showed that bus peak hour volume did not changed significantly along the segment studied after the introduction of MRT 3 service. Yet a quite significant increase in the number of non-airconditioned buses plying EDSA was noted. At the same time, data processed using the passenger-kilometer measure showed that bus passenger volume decreased after the opening of MRT 3. On the basis of bus journey time composition, there were indications that bus dwell time on bus stops increased modestly as buses had to wait longer for passengers, especially during the afternoon peak period. This in turn increased total journey time along the segment studied although there were some improvements in the average running time of buses. This could be attributed to the increase in the number of lanes previously used by the MRT 3 construction, as well as the removal of other MRT 3 construction-related obstructions.

The MRT 3 operation also introduced changes in commuter behavior. For instance, quite a large percentage of EDSA commuters were shifting modes from the bus to the MRT 3 as time can be saved along the segment of EDSA where MRT 3 operates. This resulted as more bus passengers alighting and disembarking at the end stations of MRT 3. This demonstrated behavior caused bottlenecks in said areas as it led buses to queue and sometimes block adjacent lanes of vehicular traffic.

2. METHODOLOGY

Existing travel movements defined the focus of the study. MMUTIS (1999) data showed that the critical direction along EDSA in the morning is towards the South and North for the afternoon It is critical in the sense that majority of commuters originated from the suburbs in the North for destinations in the South in the morning, and from the central business district (CBD) areas in the reverse direction in the afternoon. Hence the focus of the study is in these directions and also on the significant segment of EDSA from the Ayala Avenue and EDSA intersection to Aurora Boulevard and EDSA intersection which are points A and B, respectively, as shown Figure 1. This segment is where all bus services converge when traveling along EDSA.

By doing an onboard bus survey from the origin of the bus service line to its end point, several important variables regarding bus service and operational characteristics were obtained, such as average travel and running speeds, dwell time at stops and intersections, passenger-kilometer performance and journey time composition. These variables were compared between two time frames, that is before and after MRT 3 became operational. Volume studies were also conducted at important stations along EDSA to determine if there were changes in bus volumes operating, especially during the peak hour period.

Hypothesis testing between the two sets of sample data was the main method of determining changes in bus operating characteristics. The test procedures for comparing population means were based on the following assumptions: (1) the two samples should be drawn from different populations, hence independent of each other; (2) the two samples should be drawn from normal populations; and (3) the two population variances should be equal. These assumptions were first verified before the samples were used in the hypothesis testing.

3. PUBLIC TRANSPORT ALONG EDSA

EDSA is the main thoroughfare traverses Metro Manila from North to South. It has 5-lane roads in each direction. Before MRT 3 operated along EDSA, city buses dominated this crucial highway. Jeepneys operated only in some segments of the avenue. Since the mid-1990s, newly introduced passenger vehicles such as paratransit or megataxis, have provided intermittent service, usually during peak periods. Figure 1 shows how several bus service lines operating in Metro Manila coexisting and the newly operational MRT 3 line, whose 13 stations shown are encircled, are now along this stretch of EDSA. The newly operational MRT 3 line, whose 13 stations shown are circled, are now sharing with the buses the provision of service along this stretch of EDSA. Table 1 gives the list of bus routes and the portion of their route lengths shared with the MRT. The coded links of the bus routes are also provided.

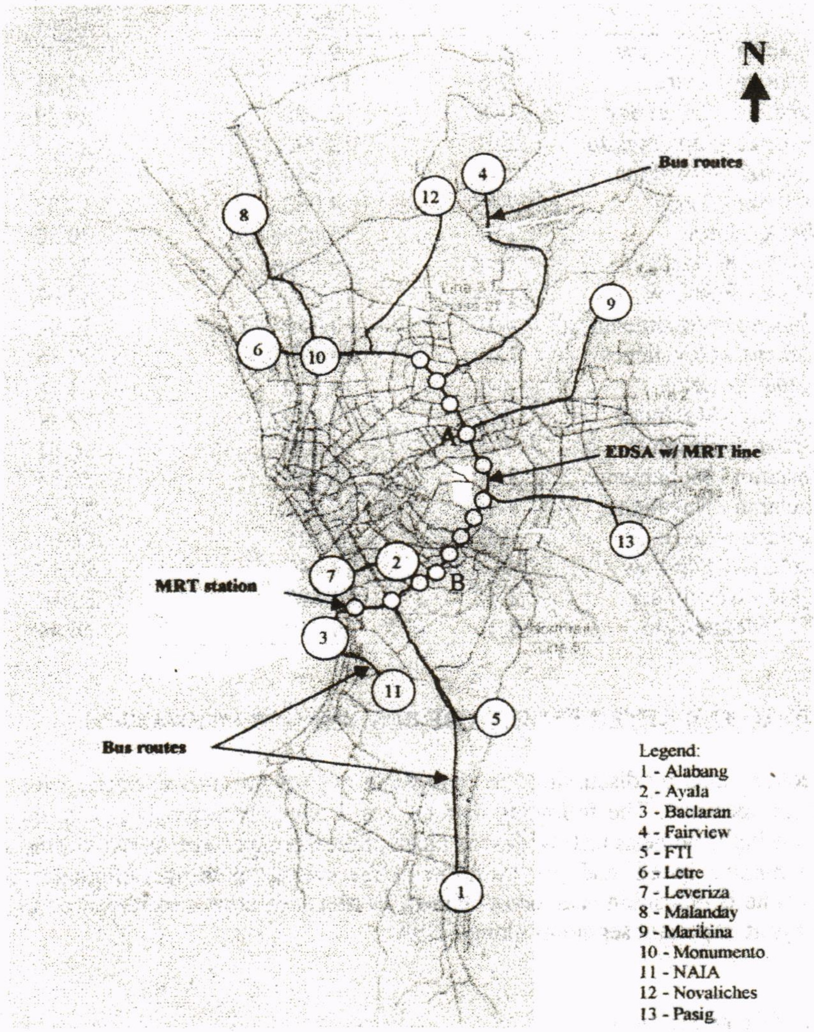


Figure 1. MRT and Bus Service Routes Passing EDSA

To date, however, MRT 3 enjoys the upper hand versus the buses given the former's reduced fares. The MRT 3 minimum fare is Php9.50 and increases by 50 centavos for every station thereafter. An entire trip costs no more than Php15. For the airconditioned buses, the current fare is Php9 for the first five kilometers, and adds on one peso for every kilometer thereafter; for non-airconditioned buses, the fare starts at Php4 for the first five kilometers and increases by 50 centavos for every kilometer thereafter.

Table 1. Bus Route Service Traversing EDSA with MRT 3 Operation

Bus Routes	Coded Links	Length of Bus Routes with MRT Service (km)	Estimated Total Length of Bus Route (km)
Leveriza – Fairview	7-4	9.915	28.90
Leveriza – Letre	7-6	12.590	24.61
Leveriza – Malanday	7-8	12.590	29.29
Leveriza - Monumento	7-10	12.590	21.62
Leveriza – Marikina	7-9	8.560	26.91
Leveriza – Pasig	7-13	4.065	13.92
NAIA – Letre	11-6	15.825	29.50
NAIA – Malanday	11-8	15.825	33.01
NAIA – Fairview	11-4	13.140	32.67
Alabang - Monumento	1-10	14.310	31.94
Alabang - Novaliches	1-12	14.310	37.15
Alabang - Letre	1-6	14.310	34.78
Alabang - Malanday	1-8	14.310	39.44
Alabang - Fairview	1-4	11.625	38.81
Baclaran - Monumento	3-10	15.825	23.35
Baclaran - Novaliches	3-12	15.825	31.23
Baclaran - Letre	3-6	15.825	26.60
Baclaran - Fairview	3-4	13.140	27.17
Ayala - Novaliches	2-12	12.590	22.90
FTI - Monumento	5-10	14.310	26.44

4. BEFORE AND AFTER STUDIES OF BUS SERVICE OPERATION

This section starts by discussing the changes in bus volume that occurred with the MRT 3 already in operation. The following data on bus service characteristics were then tested for changes using hypothesis testing: (a) the mean of the average travel speed; (b) the mean of the average running speed; and (b) the mean of the average passenger-kilometer carried. The journey time composition was also obtained. Bottlenecks were also identified using average bus delays at important segments along EDSA.

4.1 Bus Volume Study

The percentage of non-airconditioned buses plying EDSA after MRT 3 was operational increased significantly for both South (morning peak) and North (afternoon peak) directions (Table 2). Before MRT3 operation, around 60 percent and 40 percent of buses were airconditioned and non-airconditioned, respectively. The resulting bus proportions after MRT

3 offered its services were 53 percent and 47 percent of airconditioned and non-airconditioned buses, respectively.

Table 2. Comparison of Bus Volume Before and After the MRT 3 Operation

Direction of Travel and Period	Peak Hour Period (hrs)	Before		
		Aircon No. (%)	Non-aircon No. (%)	Total No. (%)
Southbound AM	6:30 – 7:30	204 (60.90)	131 (39.10)	335 (100.00)
Northbound PM	16:45 – 17:45	165 (63.46)	95 (36.54)	260 (100.00)
			After	
Southbound AM	6:30-7:30	149 (53.60)	129 (46.40)	278 (100.00)
Northbound PM	17:30-18:30	129 (52.87)	115 (47.13)	244 (100.00)

4.2 Bus Service Performance

As previously stated, several requirements need to be satisfied before the data could be subjected to hypothesis testing. The first one, both samples should be independent of each other, was fully satisfied because one data group pertained to bus service operating characteristics before MRT 3 was operational, and the second data group was on the same subject but this time, after MRT 3 was operational. The MRT 3 service provision was considered as the altering factor that was studied to determine its effect on bus service operations.

To test the normality of data, the normal probability plots of the data were determined. Figure 2 shows the normal probability plot of the average travel speed of buses in the morning peak period going South-bound before the MRT 3 was introduced. As the R^2 would show, little deviation from normality is observed as the plot follows the diagonal line. For a summary of the results of the R^2 of the average travel and running speeds samples and the critical R^2 as introduced by Looney et al (1985) as a way of determining normality of data, see Table 3. If we are to be very strict about the results, only the average travel speed of buses after the MRT is in operation passed the normality test. However, as the data would suggest, there is no significant deviation observed. Hence, the normality assumption was upheld.

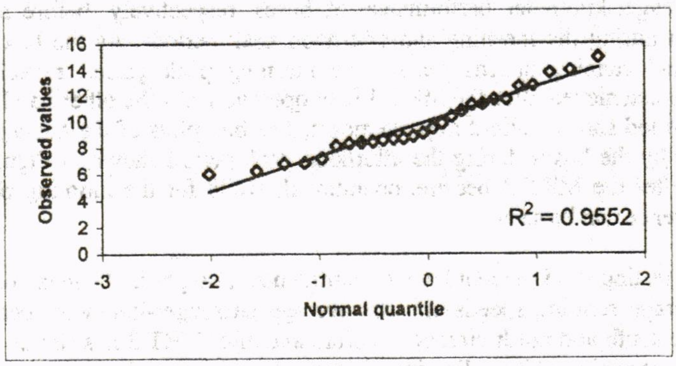


Figure 2. Normal probability plot of average travel speed before the MRT 3 operation

As to the equal variance assumption, the test statistic is F with $(N_1 - 1)$ and $(N_2 - 1)$ degrees of freedom where N_1 and N_2 are the sample sizes of groups 1 for data before MRT 3 operation, and 2 for data after MRT 3 operation.. As Table 4 shows, the South-bound average travel and running speeds of before and after studies failed to satisfy the equal variance assumption. Nevertheless, t-test for means of independent samples offers an alternative which is for data variances not assumed as equal; this was used for data that failed the equal variance assumption.

Table 3. R^2 test for normality of data using the normal probability plots

Variable	Southbound, AM Peak R^2	Southbound, AM Peak $R^2_{critical}$	Northbound, PM Peak R^2	Northbound, PM Peak $R^2_{critical}$
Before				
1. Average travel speed	0.9522	0.964	0.9197	0.964
2. Average running speed	0.9305	0.964	0.9388	0.964
3. Average passenger-km carried	0.9612	0.964	0.9577	0.964
After				
1. Average travel speed	0.9766	0.951	0.9343	0.964
2. Average running speed	0.9126	0.951	0.9192	0.964
3. Average passenger-km carried	0.9822	0.951	0.9431	0.964

Table 4. Test for Equality of Variance

Variables	Levene's Test for Equality of Variance F	P-Value	Remarks
	Southbound (AM Peak)		
1. Average Travel Speed	11.891	.001	Fail
2. Average Running Speed	20.168	.000	Fail
3. Average Pax-Km Performance	0.234	.631	Pass
	North bound (PM Peak)		
1. Average Travel Speed	3.825	.055	Pass
2. Average Running Speed	0.168	.684	Pass
3. Average Pax-Km Performance	1.445	.234	Pass

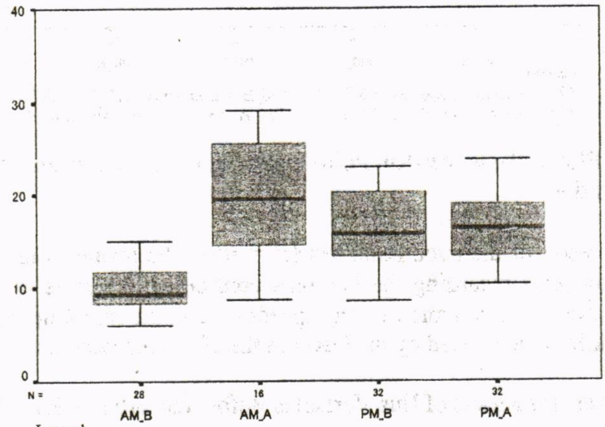
Figures 3 to 5 show the box plots of the average travel speeds, average running speeds, and the average passenger-kilometer performance of buses, respectively, before and after the MRT 3 operation during the morning and afternoon peak periods. As the box plots of the average travel and running speeds during the morning peak period reveal, significant improvements were achieved after the MRT 3 is in operation. On the other hand, data for the afternoon peak period showed slight improvements. The box plots of the average passenger-kilometer carried by the buses during the afternoon peak period shown in Figure 5 exhibits some reduction after the MRT 3 became operational; while for the morning peak data, no discernable difference can be seen.

Using hypothesis testing at 95 percent level of confidence, changes in the mean of the average travel speed, average running speeds and the average passenger-kilometer performance of buses for both the south and north directions before and after MRT 3 has started its operation along EDSA was determined. The following are the null and alternative hypothesis:

$$H_0 : \mu_1 = \mu_2 \quad (1)$$
$$H_1 : \mu_1 \neq \mu_2 \quad (2)$$

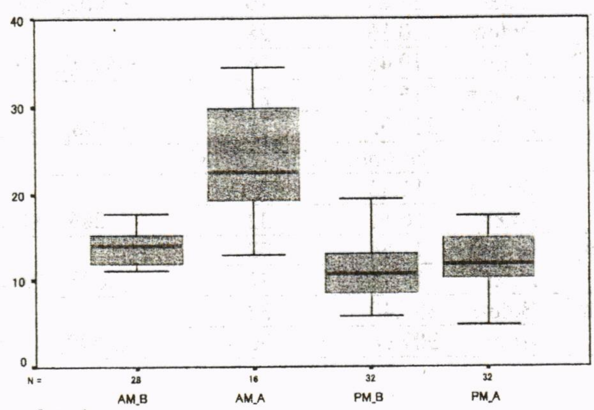
where μ_1 = the sample mean used to represent interchangeably the mean of the average travel speed, average running speed, and average passenger-kilometer performance of buses going South or North before the MRT 3 operation, and

μ_2 = the sample mean used to represent interchangeably the mean of the average travel speed, average running speed, and average passenger-kilometer performance of buses going South or North after the MRT 3 operation.



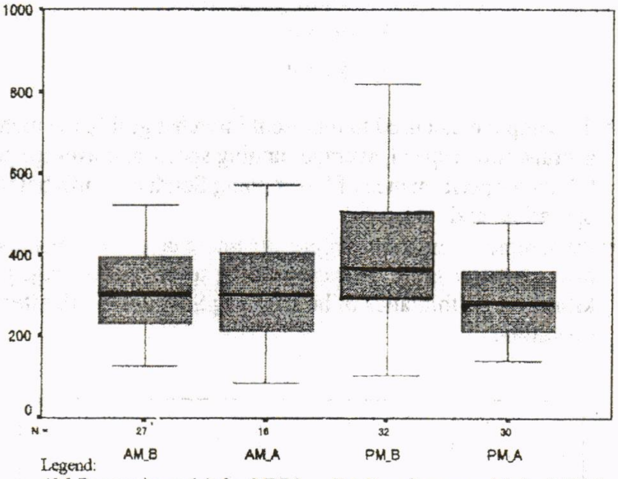
Legend:
AM_B = morning peak before MRT 3 PM_B = afternoon peak before MRT 3
AM_A = morning peak after MRT 3 PM_A = afternoon peak after MRT 3

Figure 3. Box Plots of Average Travel Speeds of Buses Before and After the MRT Operation



Legend:
AM_B = morning peak before MRT 3 PM_B = afternoon peak before MRT 3
AM_A = morning peak after MRT 3 PM_A = afternoon peak after MRT 3

Figure 4. Box Plots Of Average Running Speeds of Buses Before and After the MRT Operation



Legend:
AM_B = morning peak before MRT 3 PM_B = afternoon peak before MRT 3
AM_A = morning peak after MRT 3 PM_A = afternoon peak after MRT 3

Figure 5. Box Plot of Passenger-Km Performance of Buses Before and After the MRT Operation

Table 5 shows the result of the hypothesis test (α = .05). The results confirmed the changes exhibited in the box plots regarding the bus data considered. There is enough evidence to reject Eq. 1 for the average travel and running speeds data in the morning peak period and the average passenger-kilometer carried by the buses in the afternoon peak period.

Table 5. Test for Means of Bus Variables Before and After MRT 3 Service

Variable	Period	Mean	No. of Samples	(t-test, P-value)	Remarks
		Southbound (AM Peak)			
a. Average travel speed (kph)	Before	14.12	28		
	After	24.26	16	(-5.52, .000)	Reject H_0!
b. Average running speed (kph)	Before	10.16	28		
	After	19.45	16	(-5.802, .000)	Reject H_0!
c. Average pax-km performance	Before	316.12	27		Do not
	After	311.92	16	(.108, .914)	reject H_0!
		Northbound (PM Peak)			
a. Average travel speed (kph)	Before	16.43	32		Do not
	After	16.51	32	(-.086, .931)	reject H_0!
b. Average running speed (kph)	Before	11.54	32		Do not
	After	12.16	32	(-.695, .490)	reject H_0!
c. Average pax-km performance	Before	397.40	32		
	After	307.96	30	(2.548, .013)	Reject H_0!

4.3 Journey Time Composition

The travel time of public utility vehicles is basically divided into three parts; travel time, passenger related time, and traffic-related consumed time. Travel time is the time consumed by buses for traveling the stretch of segment being served. Passenger-related travel times are specifically that part consumed by embarking and disembarking passengers. Traffic-related consumed time is that time consumed due to traffic lights, obstruction of other vehicles and the like. For Metro Manila, in the operation of city buses, situations occur where it would be difficult to discern whether the time under consideration is passenger-related or traffic-related. For example, at intersections where buses are waiting for the traffic light to turn green, the situation can be taken advantage of by picking up passengers or sometime even wait for passengers even if the light has already turned green. In order to extract the time consumed by passengers, a polynomial linear regression equation was developed to estimate the time commuters embark or disembark from a bus public transport. Data obtained were gathered when passengers are not in anyway affected by other concerns and buses strictly stopped due to embarking and/or disembarking passengers.

From samples of embarking and disembarking passengers, with passenger numbering from a little as one to 65, the time of embarking and/or disembarking was obtained. The developed equation (Eq. 3) in a previous study (Fillone, et al, 1998) was used to estimate the time consumed by boarding and alighting passengers since it is safe to assume that no significant changes on this behavior has occurred since the previous study was conducted. The equation is given as

$$y = 2.568 + 1.958\, x_1 + 0.232\, x_2 + 0.027\, x_1 * x_2 \quad (3)$$

where y is the time consumed in embarking and(or) disembarking passengers,
x_1 is the number of embarking and(or) disembarking passengers, and
x_2 is the number of standing passengers.

As the percentages of journey time composition would show in Figure 6, the highest percentages of time were spent on movement for all sets of observations. Comparing the percentages of before and after data, during the morning peak period, less delay is experienced and percentage of moving time increased. However, for the afternoon peak period, very negligible difference can be discerned. This result supports the previous finding that improvement in average travel and running speed occurred in the morning peak period.

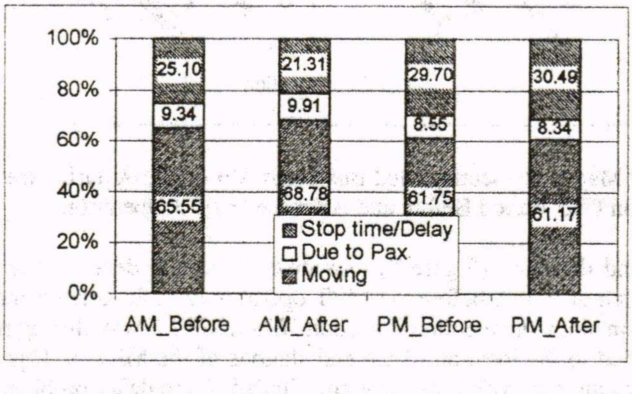


Figure 6. Bus Journey Time Composition During Morning and Afternoon Peak Periods Before and After MRT 3 Operation

4.4 Bottlenecks Along EDSA

There were some changes in the location of delays and dwell times of buses for the peak periods. For the morning peak period, before the MRT 3 service operation, the major stops where bus average overall delay was the longest is adjacent to the Shaw Boulevard and EDSA intersection bus stop (Figure 7), then followed by the Cubao bus stop. However, when the MRT 3 was already in operation, bus dwell time was longer near the North Avenue and Quezon Avenue intersections, although there was a large reduction in overall delay during the south-bound morning peak period.

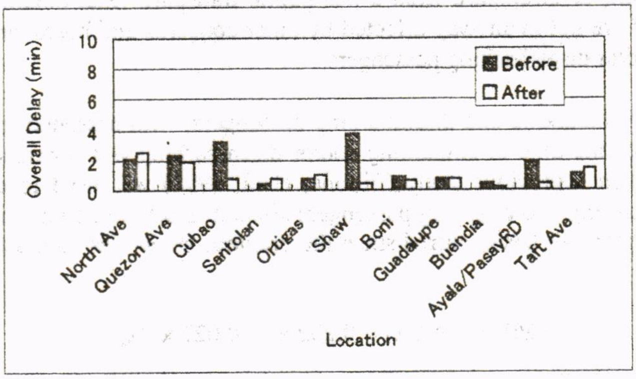


Figure 7. Delay at Major Intersections and Bus Stops Along EDSA during the South-bound Morning Peak Period Before and After the MRT 3 Operation

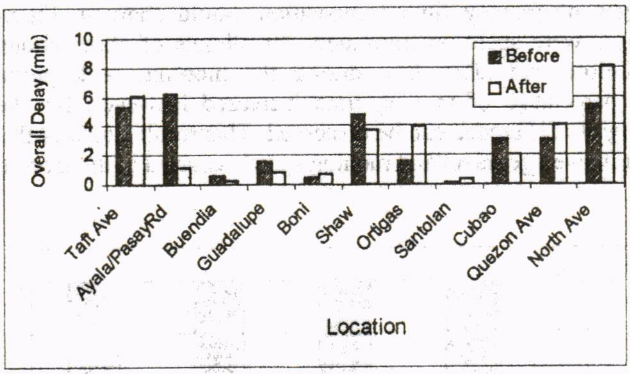


Figure 8. Delay at Major Intersections and Bus Stops Along EDSA during the North-bound Afternoon Peak Period Before and After the MRT 3 Operation

For the North-bound direction (Figure 8), bus dwell time and delay at the Pasay Road to Ayala Avenue stretch of EDSA before the MRT operation was the highest mainly due to the ongoing construction along the mentioned section. When MRT 3 was already in operation, the longest delays shifted to the location of the end stations of the MRT 3. This clearly showed that the MRT 3 terminals at both ends have contributed to the delay problem. One reason is that buses tend to drop off or wait longer for passengers going to or coming from the MRT 3.

5. CONCLUSION

The operation of the MRT system along EDSA has brought the following important developments in the public transportation system of Metro Manila, especially along EDSA:

- Public utility buses are affected in terms of the average passenger-kilometers carried as the test showed, especially for the north-bound afternoon peak period.
- The competition with MRT 3 has brought some changes in bus service operations such as
  - buses are now reducing the number of stops that they make along EDSA, thereby a significant reduction in delay is realized and proofs are the improved average travel and running speeds especially during the morning peak period, and
  - the increase in the number of non-airconditioned buses to reduce fare to make it more cheaper and affordable compared to MRT 3 and on the part of the operators, would also mean reduced operating costs.
- Choke points along EDSA have shifted to locations such as the Taft Avenue and EDSA intersection mainly due to mode changing by commuters so that public transports such as buses and jeepneys converge near the MRT 3 terminal.

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