Examining the MMDA Bus Segregation Scheme in EDSA

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Abstract: EDSA is considered as the major road network in Metro Manila faced with various challenges. Different transport demand management (TDM) measures have been introduced to ease up the traffic congestion, such as the HOV lane, odd-even scheme, and bus segregation scheme. The intention of this paper is to observe the Total Travel Time of buses along EDSA based on the 2012 Bus Segregation Scheme of MMDA. Number of stops, dwell time at the designated stops and the number of stops are the variables affecting total travel time is the main hypothesis in the study.

The 2013 secondary Bus Passenger Survey Data along EDSA from the paper of Dr. Fillone titled, *"An Integrated and Optimal Schedule of Public Transport Operations in Metro Manila"* was used in the study. Multiple Linear Regression Results showed that Total Travel Time of buses in EDSA is significantly affected by the Dwell time at the bus stops and the bus types.

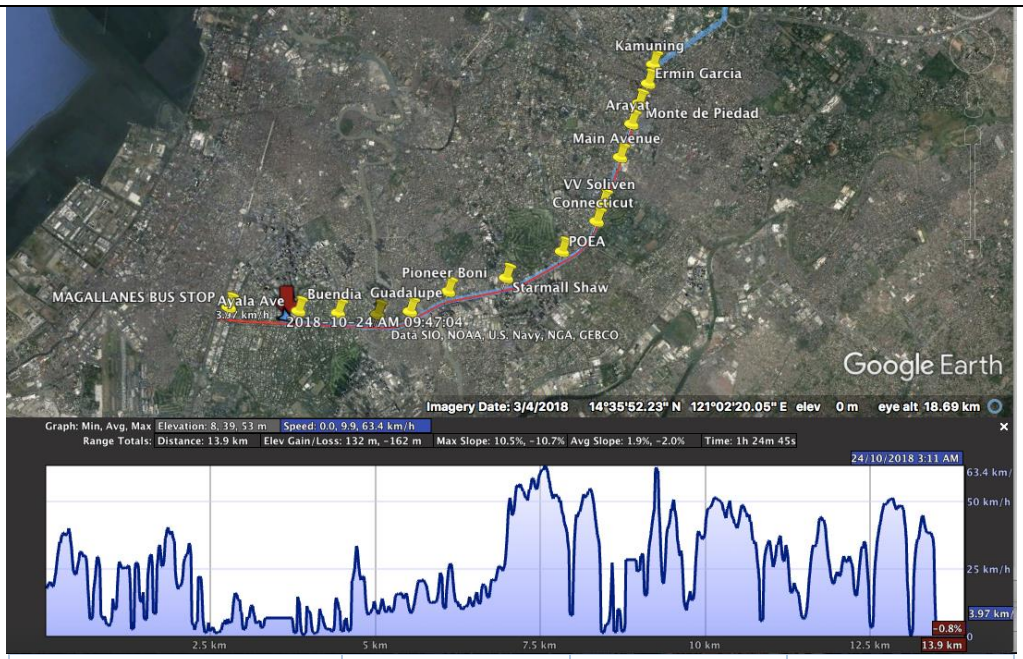
Keywords: Public Transport, Bus Segregation, Travel Time

1. INTRODUCTION

During the *Workshop on Sustainable Urban Mobility in Manila* last October 22-26, 2018 the UP-SURP group assigned to observe the bus travel time from UP Diliman to SM Makati obtained the minimum, average and maximum speed per segment or bus stop along EDSA using the "myTracks" mobile application (http://www/mytracks4mac.com/). Figure 1 shows the tabulated segments and the stops along EDSA from UP Diliman to SM Makati from the random bus ridden by the SURP students and Germany student representatives.

The data obtained from the myTracks mobile application, was converted to a GPX file that can be used in any GIS software. From here, the minimum speed, maximum speed and average speed per stop are graphically presented in Figure 2.

Aside from using the myTracks app, the group also observed that the Metro Manila Development Authority (MMDA) Bus segregation scheme is strictly followed by some buses, while others do not. Thus, interest to examine the operations of the bus segregation scheme of MMDA along EDSA using total travel time as a criteria.



Segment	Min (Km/Hr)	Ave (Km/Hr)	Max (Km/Hr)
Kamuning - Ermin	2.7	6.8	16.3
Ermin - Monte	3.8	7	7.1
Monte - Arayat	0.7	2.6	14.9
Arayat - Main	1.9	5.2	33.6
Main - Soliven	8.3	13.2	23.7
Soliven Connecticut	10.2	13.6	27.2
Connecticut - POEA	11.2	24.5	57.7
POEA - Starmall	1.5	9.3	63.4
Starmall - Pioneer	1.8	17.3	62.9
Pioneer - Guadalupe	5.9	31.8	51.6
Guadalupe - Estrella	6.3	18.4	37.6
Estrella- Buendia	15.1	27.2	44.3
Buendia - Ayala	0	14	51.5
Ayala - Mantrade	3.1	29.3	45.1

Figure 1. Speed at different segments of EDSA

According to MMDA, more than 3,600 city buses ply EDSA on a daily basis, while another 7,368 provincial buses whose companies have designated terminals in the metropolis also use the same highway, adding to the volume of vehicles that share this main thoroughfare. These city buses are only allowed to use the two rightmost lanes of EDSA commonly called the yellow lanes. Traffic congestion were observed to be common in most of the bus stops along EDSA.

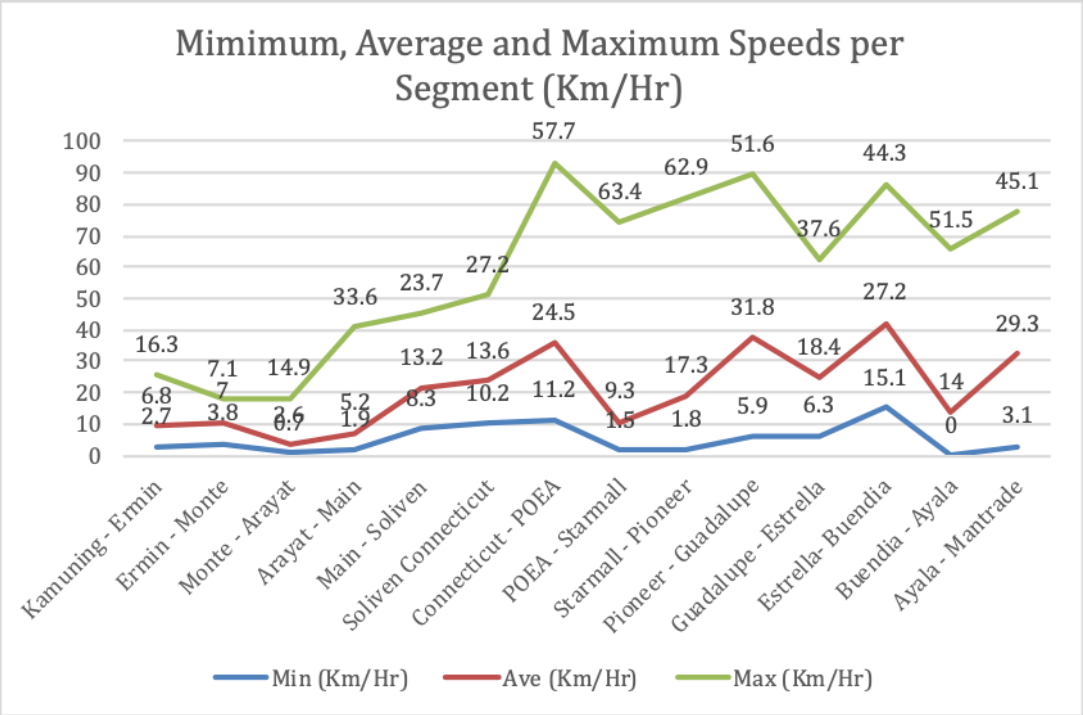


Figure 2. Consolidated Speed Graph of the bus rode along EDSA

In order to alleviate traffic congestion, on 18 December 2012, the MMDA through the chairmanship of Atty. Francis Tolentino approved the bus segregation scheme along EDSA through the signing of the *MMDA, 2012 Transport & Management MC No. 15*. The main objective of this policy is to reduce traffic congestion along EDSA thoroughfare particularly in the loading and unloading areas.

Table 1. Direction per Bus Type and Number of Stop Assignments

Direction	No. of Stops	Assigned bus stop
Southbound		
• Bus A	8	Ermin Garcia, Arayat Cubao, W. Soliven, Connecticut, Shaw Star Mall Guadalupe, Buendia, and Mantrade
• Bus B	7	Kamuning, Monte de Piedad, Main Ave., POEA Ortigas, Pioneer, Estrella, and Ayala
• Bus C	15	All stops (combination of A & B)
Northbound		
• Bus A	8	Magallanes, Buendia, Guadalupe, Shaw Blvd, SM Megamall, B. Serrano, Cubao Farmers, and Ermin Garcia
• Bus B	7	Ayala, Estrella, Pioneer/Boni, SM Megamall, Ortigas, Main Ave., Baliwag 5-Star, and Kamuning
• Bus C	15	All stops (combination of A & B)

Source: MMDA, 2012 Transport & Management MC No. 15

Under the MMDA bus segregation scheme one bus type named as "C' is allowed to stop, and load and unload passengers in the 15 bus stops along EDSA. Bus types "A" and "B" are allowed to stop, and load and unload passengers in bus stops exclusively assigned to them, i.e. "A" bus type are those that ply the EDSA-Alabang route and will only stop to pick-up or unload passengers at "A" bus stops; while "B" buses are those that ply the EDSA-Baclaran route and will only stop at "B" bus stops; and "C" bus can stop in all bus stops on both northbound and southbound route. Table 1. Direction per Bus Type and Number of Stop Assignments summarizes the MMDA Bus Segregation Scheme.

By examining the total travel time along EDSA with the MMDA Bus Segregation Scheme, a baseline of the current scenario can be established. The authors were able to find out that there was no data on the Total Travel Time along EDSA prior the start of the MMDA Bus Segregation Scheme, that can be used as basis of comparison. From these study, if there will be amendments or modifications to the current scheme, comparative study can also be done, similar to a pre-test and a post-test research design. Possible modifications to improve the Bus Segregation Scheme that were observed in the literature were the bus design and the design of the bus stops as the two major parameter affecting Total Travel Time.

1.1 Research Questions

The study focuses on the EDSA, with East Avenue as the starting point and Magallanes Interchange as endpoint for Southbound buses and vice versa for Northbound buses, as this whole stretch was the coverage of the MMDA Bus Segregation Scheme and shall attempt to answer two research questions:

1. What are the factors affecting the Total Travel Time of the segregated buses in EDSA?
2. How will the bus direction affect the Total Travel Time of the segregated buses in EDSA?

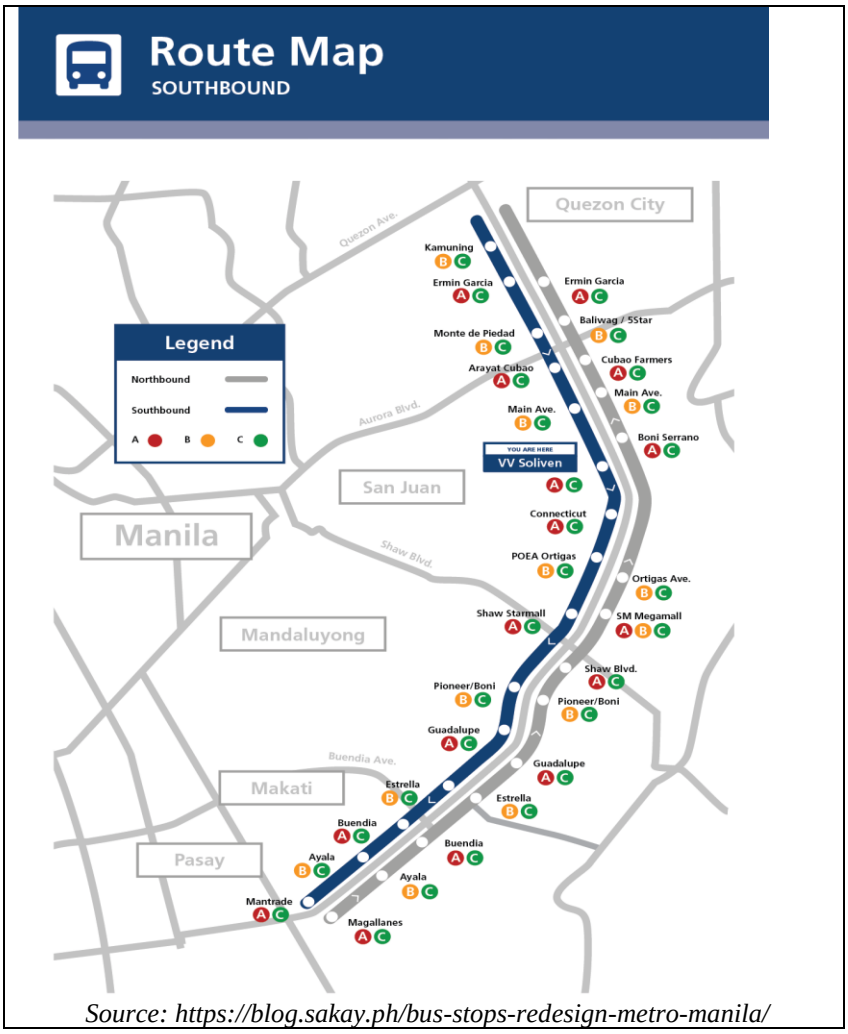
1.2 Objectives of the Study

Accordingly, the study aims to achieve two objectives:

1. to determine the factors that affect the Total Travel Time of buses along EDSA; and
2. to identify if the Total Travel time is different for each direction (Northbound and Southbound)

1.3 Study Area

The study area will focus on EDSA, with East Avenue as the starting point and Magallanes Interchange as endpoint for Southbound buses and vice versa for Northbound buses, as this whole stretch was the coverage of the MMDA Bus Segregation Scheme. With designated bus stops per bus type (A, B and C) as reference for the total dwell time, number of passengers boarding and alighting, and the time consumed going in between designated bus stop and the whole trip itself as basis for the total travel time.



Source: https://blog.sakay.ph/bus-stops-redesign-metro-manila/

Figure 2. MMDA Bus Segregation Scheme – Bus Type and Stop Assignments

1.4 Limitations of the Study

Paper depended on the 2013 secondary data of Dr. Fillone, where the following are the only available data:

Time of bus entry and exit along EDSA		Bus Type (A, B, C)
Number of passengers that alighted and boarded the bus at the designated and non-designated stops		Bus condition (air-condition, non-aircondition)
Time in minutes the bus stop at designated and non-designated stops		Bus Route (O-D)

In addition, there was no actual speed recording per bus, thus average speed used in the multiple regression were only computed from available data.

Although the intent of the study is to examine the effect of bus segregation scheme along EDSA on the total travel time, no comparison was made between travel time with and without the bus segregation scheme due to issues on data availability prior the implementation of the Bus Segregation Scheme.

2. REVIEW OF RELATED LITERATURE

In transportation planning literature, the Origin-Destination (OD) matrix is used to represent flow from source nodes to sink nodes for algorithm use (Bell, 1997). On top of the OD matrix, the four-step model which includes trip generation, trip distribution, travel mode choice, and trip assignment has been the leading approach to modeling travel demand. This process identifies the traffic impacts on the whole transportation system through the estimation of traffic flow on each segment and its comparison with the capacity (McNally, 2007). In this paper, selected articles that focus on Travel Time; Dwell Time; and Bus Planning and Operation & Assessment were reviewed based on their models, methods, and results.

Transit travel time studies conducted have used dwell time as the basis of to measure the performance of the bus operators.

The independent variable T is the total stopped time per bus in seconds while the "n" is the number of interchanging passengers per bus stop. Variations in dwell time is usually a result based on the specific route's land use or zoning. Among the other variables used in the study of Levinson included the type of route and type of stop varying among urban areas that reflect the volume of the passengers.

Kho (2013) said that bus dwell time is one of the major factors that affects the bus' Level of Service (LOS). Additional parameter that he has identified is the peak hour and off-peak hour, which he categorized as follows: peak hour period is 8am to 9am and 5pm to 6pm, while the non-peak hour is 9am to 10 am and 4pm to 5pm. Other factors that he considered were the payment method (cash or card and conductor system), platform crowding level and the boarding and alighting activities of the passengers.

Sun, et.al (2014) introduced the bus type classification base on its characteristics as parameters for the bus dwell times. There model presents the concept that total time for boarding and alighting for each service and stop is also affected by the bus design, i.e. double or single decker and low or high step/floor entrance. Approached used is through a multiple linear regression, which resulted in the variability of boarding and alighting times have likely but unknown effects on the bus interval variability and consequently to the dwell time of buses at stops.

Speed is considered as one of the factors for the travel time, however most often than not, the acceleration and deceleration of the vehicles also plays a crucial role in the travel times. Zhurui, et.al (2016) introduced these variables in their model using descriptive statistics method to analyze dead time in the bus operations in China buses.

According to Liu, et al (2017) said that bus operation efficiency is important to urban traffic systems as it is crucial for the bus travel times and the quality of service for the passengers and reduction of operating cost for the operators. He argued that travel time may be reduced by reducing loses at intersections, bus stops, use of bus lane, etc. In their study, they argued that the bus stop design is also a factor that impacts the travel time and over-all performance of the bus operation. From the bus designs, there are currently three common bus stops: bus bay, curb-side stop and bus bulb. They argued that from these designs, the acceleration time and deceleration time of the buses depends on the cruising speed to a full stop when approaching

the bus stop. Though, they did not compute for the speed directly but used the bus stop design as a categorical variable.

It was observed that some of the related literature on the bus travel time and dwell time used also GPS and heat maps to also measure the level of service (LOS) in the different times of the day to support the statistical analysis conducted.

Kho (2013) in his study about the Klang Valley region in Malaysia's bus operation, he had collected dwell time data from 20 bus stops and used video recording as a means to document the data instead of tapping surveyors to conduct the survey. In each stop he recorded the number of bus that approached and the time it stayed at the bus stop. In his model, he used two approaches: probability distribution and regression modelling.

In order to determine the goodness of fit of the model made by Kho (2013) he adopted the Chi-square test for the probability density function and the Kolmogorov-Smirnov and Anderson-Darling test for the cumulative distribution. Results have shown that accuracy and level of significant is -.05 and 95% respectively. Stepwise multiple regression using a statistical software was used and the best regression with the highest R^2 is chosen in his study. As a conclusion, during peak and off-peak there are variability in the dwell time.

When these variables were used, in the study it showed that the volume of passengers boarding and alighting have significant impact on the dwell time. While the vehicle type (low- or high-floor), from the time of the day (peak, off-peak, inter-peak), and from the location of the stop (city center, close to POIs) are also considered significant factors affecting dwell time.

Sadeghpour and Ogut (2016) prepared a different study in Istanbul focusing on the boarding and alighting service times of urban bus transportation. Approach is similar to the one conducted by Kho, where the bus arrival and departure time were observed in four (4) different bus stops in Istanbul. Two separate multiple regression models, (1) boarding and (2) alighting, were used to show that gender and age of the passengers, bus crowdedness and bus floor heights affect the dwell time of buses at bus stops. Their study had shown that Women's boarding and alighting service time is bigger than men. Alighting passengers, bus crowdedness and floor bases show no significant statistical difference.

Zhirui, et al (2016) used a comparative approach on the different bus stop designs and run a multiple linear regression to determine the bus dwell time and the time lost for serving stop in China. Based on their study, *results showed that the differences taken at near-side and far-side stops and near-side and mid-block stops during peak and non-peak periods were all statistically significant. However, the differences taken at far-side and mid-block stops were not statistically significant. The findings further indicated that near-side stops could result in longer dwell time and time lost serving stop than the other two types of bus stops.* In addition, they introduced other variables such as weather conditions, passenger behavior as additional factors to consider for the lost in serving stop in China.

In Singapore, the results of Liu, et.al (2017) showed that for curb side bus stop, it required shorter boarding and alighting time per passenger. This is because curb side stops, compared with bus bays have similar deceleration times, shorter than the acceleration time.

3. CONCEPTUAL FRAMEWORK

In this paper, it is assumed that the Total Travel is affected by the number of stops and, dwell time and the bus type. Since the Dwell Time per bus stop is affected by volume of boarding and alighting passengers, and might correlated and affect the goodness of fit of the model. The variables identified were based on the different related literature reviewed for this paper. However, as mentioned in the limitation of the study, some variables from the RRL were not considered since the data are not presently available and if available it might not be the data that explains the model because the year might be different (2015 from Dr. Fillone and 2018 data acquired).

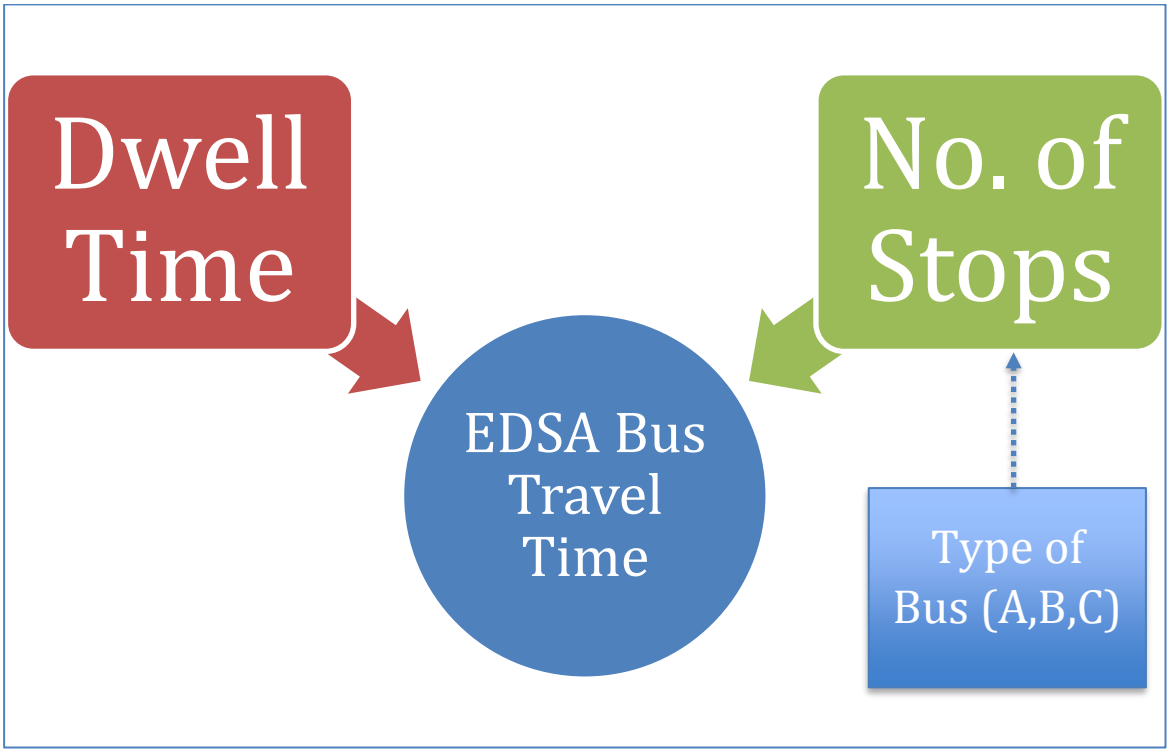


Figure 3. Conceptual Framework for the EDSA Bus Travel Time

4. ANALYTICAL FRAMEWORK

From the conceptual framework, this part of the study describes the process the expected interaction of the variables identified and the EDSA Travel Time Model is introduced.

$$TT_{EDSA} = \alpha + NS\beta_0 + DT\beta_1 + +BTy\beta_2 + \varepsilon$$

Where:
$TT_{EDSA} = Total\ Travel\ Time\ of\ Buses\ in\ EDSA$
$NS = Total\ Number\ of\ Bus\ Stops\ along\ the\ EDSA\ Route$
$DT = Total\ Dwell\ time\ at\ Designated\ and\ Non-Designated\ Stops$
$BTy = Bus\ Type, whether\ A, B\ or\ C$
$\varepsilon = Error\ Term$

It is assumed that the TT_{EDSA} has a direct relationship with all the dependent variables identified in the equation, meaning as the $NS\beta_0$ increases, the TT_{EDSA} base on the coefficient β_0. This is shown in Table 2. Hypothesis and measures.

Table 2. Hypothesis and Measures

HYPOTHESIS	MEASURE
The number of bus stops taken along EDSA is directly proportional to Total Travel Time	If number of stops increase/decrease, total travel time shall increase/decrease
The amount of dwell time at bus stops is directly proportional to Travel Time	If Dwell time at bus stops increase/ decrease then total travel time shall increase/ decrease
The count of bus per bus type is directly proportional to Travel Time	If Dwell time at designated bus stops increase/ decrease then total travel time shall increase/ decrease

Ideal models should have:

- Coefficients with correct sign
- Coefficients with great significance where in P-Value (T-statistic Is =< 0.000), the closer the better
- R-squared is approaching 1.0 or at the least 0.7

Multiple linear regression model was used in the study, to show that the variables are indeed directly affecting the Bus Travel Time in EDSA. However, some of the variables processed showed high correlation, thus making the signs irrelevant. These variables were dropped in the Total Travel Time of Buses in EDSA are: Peak Hours, Speed, Number of passengers, number of designated stops and passengers boarding and alighting, number of non-designated stops and passengers boarding and alighting, and the bus condition (whether AC/Non-AC).

5. METHODOLOGY

5.1.Data Gathering

The data used in this study were from the funded project of Dr. Alexis Fillone titled "*An Integrated and Optimal Scheduling of a Public Transport System in Metro Manila (PUBFix)".* The data contains the type of bus in accordance to the MMDA segregation scheme, the bus profile, stations and stops of the bus, time at each stop, and the number of boarding and alighting passengers. In the mentioned paper, surveyors were hired to conduct the Bus Stop/commuter OD survey (with 7,000 samples).

To achieve the objective of the paper, the 7,000 samples on Bus Stop commuter OD survey were reviewed. The authors selected only the samples that used EDSA for the trip. A total of 131 samples were identified that qualifies the criteria of passing through along EDSA. However, when data were validated, only 124 samples have the complete and correct data needed for the multiple linear regression.

The data profile of the bus includes the name of the operator, bus driver, plate number, condition (AC/non-AC), its route, time it started to depart the terminal, moving time, stop time, number of passengers embarking (boarding) and disembarking (alighting), time at the designated stops. The time is reflected in hours, minutes and seconds.

From this data, the authors was able to extract the time the bus entered Magallanes if northbound and Kamuning if Southbound, and the time it reached the next station, the number of stops made by the bus and the number of specific passengers that alight and board the bus per station. In terms of time or the duration in transit or at stop, the hours were converted to minutes and the seconds were also converted to minutes. From here, the authors were able to generate the dwell time in minutes for the designated and non-designated stops.

5.2.Data Analysis

The distance was manually generated by one of the authors using google maps, this was done used to compute the speed in meters/minute for the bus.

The peak hours that was considered in the study is the same as the peak hours and off-peak hours identified in a study related to P2P, which is as follows:

AM Peak – 5am – 10am
PM Peak – 5pm – 8pm
Off peak – 10:30 – 4:30 pm

For each bus type there is only a specific number of bus stops, therefore the authors were also able to identify the designated and non-designated stops using the MMDA matrix for the bus segregation scheme.

A multiple linear regression is used to explain that the dependent variable Total Travel Time is affected by the identified dependent variables. In order to process the data, the authors used the MS Excel to process the data at hand and then converted it to a STATA ready format (CSV) for easy importation of data sets.

Correlation and multiple linear regression analysis was run using the STATA to explain the behavior of the identified variables using the equation shown under the Analytical Framework as indicated below:

$$TT_{EDSA} = \alpha + NS\beta_0 + DT\beta_1 + +BTy\beta_2 + \varepsilon$$

6. PRESENTATION AND ANALYSIS OF RESULTS

6.1. Descriptive Analysis

A total of 131 Bus travel records were obtained from the DLSU. However only 124 of which are valid data sets for processing in the study. The succeeding tables summarizes the data used in the study.

Table 3. Frequency of Buses per direction and bus type

Direction	Bus Type	Number of bus
North		**54**
	A	27
	B	16
	C	11
South		**70**

	A	25
	B	27
	C	18
TOTAL		**124**

There are 54 bus observations going to the North, while there are 70 bus observations going to the South. With the difference in the number of observations, it might generate a different regression results if it will be clustered base on the directions.

Table 4. Frequency of Buses per bus type

Bus Type	**North**	**South**	**TOTAL**
A	27	25	52
B	16	27	43
C	11	18	29
TOTAL	**54**	**70**	**124**

In addition, there are only 29 Bus Type C buses that was surveyed, which is low as compared to the Type A with 52 and B with 43 observations. Again, this differences in the numbers might lead to an error when the model is run in the Stata.

In terms of the bus condition, there are 73 buses that are Air Conditioned while 50 were non-Air Conditioned, and only 1 bus was identified. While the average speed of the buses when they enter Magallanes/Kamuning and exits Kamuning/Magallanes is 24.874km/hr only (414m/min); average travel time in minutes is 49.71 minutes.

Table 5. Ave. Speed, and Transit & Dwell Time of Buses from Magallanes to Kamuning

	Average Speed	**Average Travel Time**	**Average Dwell Time**
Magallanes-Kamuning	24,874km/hr	49.71mins	34.95mins

This means that the total transit time of buses in EDSA is 49.71 minutes on the average at a speed of 24.874km/hr. While the Average Dwell Time at the bus stops is 14.76 minutes only and the Average Running Time of buses in EDSA is 34.95 minutes. These data are only reflective of the 124-sample size used in this study, where the time varies from peak and off peak hours.

6.2. Inferential Analysis

Numerous multiple linear regressions using different dependent variables were run, but this shown the best R2 and correct signs and acceptable P-values for the variables, thus this is the only model shown in the results and discussion portion of the paper.

Using the Travel Time of EDSA bus in the analytical framework for the regression, Figure 8 shows the Stata results with an R^2 of 0.407.

$$TT_{EDSA} = \alpha + NS\beta_0 + DT\beta_1 + BTy\beta_2 + \varepsilon$$

```
. regress TotalTraveltimeinminutes BusA BusB BusC TotalNumberofStops TotalDwellTime
note: BusA omitted because of collinearity
```

Source	SS	df	MS		
Model	11291.7934	4	2822.94834	Number of obs	= 124
Residual	16450.3009	119	138.237823	F(4, 119)	= 20.42
				Prob > F	= 0.0000
				R-squared	= 0.4070
				Adj R-squared	= 0.3871
Total	27742.0943	123	225.545482	Root MSE	= 11.757

TotalTraveltimei~s	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
BusA	0	(omitted)				
BusB	1.083192	2.533941	0.43	0.670	-3.934265	6.100649
BusC	1.947808	2.979681	0.65	0.515	-3.952258	7.847875
TotalNumberofStops	.9996466	.2704708	3.70	0.000	.4640875	1.535206
TotalDwellTime	.6992934	.0996762	7.02	0.000	.5019246	.8966623
_cons	22.38413	4.305589	5.20	0.000	13.85863	30.90962

Figure 4. Regression Results for TT using NS, DT and Bus Type

Variables:

TT- Total Travel Time
ND- Total Number of Stops
DT- Total Dwell Time
B_{TyA}- Bus Type A
B_{TyB}- Bus Type B
B_{TyC}- Bus Type C

Regression Model/Equation:

TT_{EDSA} = .99NS + .69DT + 1.08 BTB + 1.94 BTC

6.3. Interpretation

The regression model shows that the *Total Number of Stops, Total Dwell Time and the Total No of Bus per Bus Type* directly/positively affects the *Total Travel Time.*

The value of **R-squared** for the whole equation is at **0.40**, lower than the far from the desirable value of at least 0.7 to 1.0, nonetheless is still acceptable. For the P value (t-statistic) of all independent variables, sans the bus type, shows high degree of relationship to the independent variable.

The Total Travel Time of EDSA buses was also run base on the direction, regression analysis for North and South are as shown in the succeeding Stata results. However, it is observed that the R^2 for the South direction is 0.50 while the R^2 for the North direction is only 0.33. This is

probably due to the difference in the sample size. There are 70 observations in the South direction while there are only 54 observations in the North direction.

Regression per Direction (North)

For the North direction, Bus Type B and A has showed that if Bus Type A and B decreases, Travel Time in EDSA going to the North decreases.

$$TT_{EDSA\text{-}North} = 0.70NS + .55DT - 2.06\ B_{TyB} - 7.44\ B_{TyA}$$

```
-> Direction = 1
note: BusC omitted because of collinearity

      Source |       SS       df       MS              Number of obs =      54
-------------+------------------------------           F(  4,    49) =    6.26
       Model |  4655.45198     4    1163.863           Prob > F      =  0.0004
    Residual |  9108.37247    49  185.885152           R-squared     =  0.3382
-------------+------------------------------           Adj R-squared =  0.2842
       Total |  13763.8245    53  259.694801           Root MSE      =  13.634

------------------------------------------------------------------------------
TotalTraveltimei~s |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------------+----------------------------------------------------------------
     TotalDwellTime |   .5514892   .1572703     3.51   0.001     .2354427    .8675356
TotalNumberofStops |   .7077831   .5071979     1.40   0.169    -.3114694    1.727035
              BusA |  -7.449445   5.478392    -1.36   0.180    -18.45869    3.559796
              BusB |  -2.064515   5.486792    -0.38   0.708    -13.09064    8.961607
              BusC |          0  (omitted)
             _cons |   35.06295   11.01909     3.18   0.003     12.91926    57.20663
------------------------------------------------------------------------------
```

Figure 5. Regression Results for TT using NS, DT & Bus Type – North Direction

Regression per Direction (South)

For the South direction, Bus Type B and A has showed that if Bus Type A increases by 1.89 units and B increases by 0.39 units, Travel time increases for the South Bound buses in EDSA.

$$TT_{EDSA\text{-}South} = 17.92NS + .83DT + 0.38\ B_{TyB} + 1.89\ B_{TyA}$$

```
-> Direction = 2
note: BusC omitted because of collinearity

      Source |       SS       df       MS              Number of obs =      70
-------------+------------------------------           F(  4,    65) =   16.59
       Model |  6873.00575     4  1718.25144           Prob > F      =  0.0000
    Residual |  6730.63103    65   103.54817           R-squared     =  0.5052
-------------+------------------------------           Adj R-squared =  0.4748
       Total |  13603.6368    69  197.154156           Root MSE      =  10.176

------------------------------------------------------------------------------
TotalTraveltimei~s |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------------+----------------------------------------------------------------
     TotalDwellTime |   .838826    .138116     6.07   0.000     .5629892    1.114663
TotalNumberofStops |   1.153493   .3022236     3.82   0.000     .5499102    1.757075
              BusA |    1.89741   3.421835     0.55   0.581    -4.936467    8.731287
              BusB |   .3824297   3.273755     0.12   0.907    -6.155711     6.92057
              BusC |          0  (omitted)
             _cons |    17.9243   6.091192     2.94   0.005     5.759349    30.08925
------------------------------------------------------------------------------
```

Figure 6. Regression Results for TT using NS, DT & Bus Type – South Direction

Another error (aside from the items mentioned in the Descriptive Analysis) that could have led to the small R^2 and difference in the regression results for the North and South direction is the presence of bus that has routes that will pass enter EDSA in Buendia instead of the Magallanes/Kamuning. There are also buses that reached only the Ortigas, since its route is from Pasay to Antipolo and vice versa.

6.4. Results of Correlation Analysis

$$TT_{EDSA} = \alpha + NS\beta_0 + DT\beta_1 + BTy\beta_2 + \varepsilon$$

```
. correlate TotalDwellTime TotalTraveltimeinminutes TotalNumberofStops BusA BusB BusC
(obs=124)
```

	TotalD~e	TotalT~s	TotalN~s	BusA	BusB	BusC
TotalDwell~e	1.0000					
TotalTrave~s	0.5605	1.0000				
TotalNumbe~s	0.1371	0.3751	1.0000			
BusA	-0.1108	-0.2112	-0.3768	1.0000		
BusB	-0.0976	0.0035	0.1447	-0.6192	1.0000	
BusC	0.2389	0.2422	0.2766	-0.4695	-0.4026	1.0000

Figure 6. Correlation Results for TT using NS, DT and Bus Type

As discussed during previous literature, speed of buses may also be considered as a variable affecting total travel time. Below are results of the regression and correlation analysis. The data presented was that of Total Travel Time as the dependent variable (Y) while the independent variables are Total Dwell Time, Total Number of Stops, Total Passengers, Bus Types and the Speed for all directions. At all directions the R-squared are within acceptable levels as well as the P-Value. The signs of the coefficients are consistent as well stating the negative relationship of Total Passengers to the Y variable however, it's P-value remains far from desirable levels stating low significance. On the other hand, speed poses a negative relationship with the Total Travel Time interpreted as when minimum speed increases the total travel time decreases.

```
. correlate TotalTraveltimeinminutes TotalDwellTime TotalNumberofStops TOTALPASS BusA BusB BusC Speedmmin
(obs=124)
```

	TotalT~s	TotalD~e	TotalN~s	TOTALP~S	BusA	BusB	BusC	Speedm~n
TotalTrave~s	1.0000							
TotalDwell~e	0.5605	1.0000						
TotalNumbe~s	0.3751	0.1371	1.0000					
TOTALPASS	-0.1849	-0.0237	-0.0805	1.0000				
BusA	-0.2112	-0.1108	-0.3768	0.1680	1.0000			
BusB	0.0035	-0.0976	0.1447	-0.2357	-0.6192	1.0000		
BusC	0.2422	0.2389	0.2766	0.0691	-0.4695	-0.4026	1.0000	
Speedmmin	-0.3523	0.1031	-0.0937	0.1944	0.1414	-0.1137	-0.0369	1.0000

Figure 7. Correlation Results for TT using NS, DT, Bus Type, Speed and Total Passenger

7. CONCLUSIONS AND RECOMMENDATIONS

Travel Time of buses in EDSA is significantly affected by the Dwell time at the bus stops and the bus types. However, the problem with the 124 data that was processed. Results may also be

applicable only for this specific study and may not apply to all. However, the Travel Time of buses model developed can explain that if the dwell time is reduced by one (1) minute through the reduction of bus stops along EDSA, by strictly observing the designated bus stops per bus type, travel time of buses along EDSA will improve by 1 minute and 9 seconds.

However, in reference to the R^2, the model is saying that there are other factors that still affect the travel time of buses along EDSA and these factors may be the variables that were dropped due to correlation or unavailability of data.

Differences in the regression results for the north and south direction results from the variance in the sample size for the North and South buses. These factors probably contributed to the error in the model. The sample size of 124 is small as compared to the sample size used in various literatures reviewed for this study.

The R^2 of the study may have been similar to one of the reviews of related literature discussed in this paper, but the following are still the recommendations in order to improve the Bus Travel Time Model in EDSA:

- Introduce other parameters that were not part of the data available such as:
    - Length of the bus stop (since bus stop design in EDSA are all curb side stop except for SM Megamall that has a Bus Bay)
    - Number of bus doors in a bus (some bus only has one door at the front and most of which are air-conditioned buses), it it has a front and rear door.
    - Distance to the next available transport mode or point of interest/destination of the passengers
    - Passenger profile, gender and age, origin and destination, etc
    - Facilities at the bus stops, such as roofs/chairs
    - Days in the week, might also affect the number of passengers
    - Weather condition as cited in one of the literatures reviewed.
- Consider conducting another survey similar to the ones conducted in 2015, to determine if the same bus travel time is still being observed in EDSA now that there are P2P buses operating along EDSA and there are some technical failures in the MRT.
- Consult with MMDA the basis for the selection of the bus stops per bus type and if available, baseline data before the introduction of the Bus Segregation Scheme in order to come up with a more concrete basis of comparison to assess the transport demand management (TDM) measure introduced has indeed reduced traffic congestion.
- The sample size should be increased and the whole round trip of the bus should be recorded and for each bus routes, there should be an acceptable number of observations. Since some of the sample size in the study included buses that only started in Buendia and some even ended until Ortigas only.

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