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Modelling Travel Time Reliability of Public Bus Transport: A Case Study of Airport to Narayan Gopal Chowk Route, Kathmandu

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Abstract

The aim of this paper is to develop a model for travel time reliability of public bus transport of Airport to Narayan Gopal Chowk Route, Kathmandu. On board technique was adopted to collect the data. In this technique, enumerators traveled in bus of the study route and the different delay and travel time were noted down using a stopwatch. For the purpose of modelling travel time reliability, the planning time, mean travel time and different unexpected delay were used. Multiple linear regression analysis technique was adopted to model the travel time reliability in SPSS (Statistical Package for the Social Sciences) software. The dependent variable in this research work is planning time and where as the independent variables are mean travel time and different unexpected delays i.e., unexpected delay at bus stop(D_{bs}), unexpected delay due to stopping at undefined curb stop(D_{ucs}),unexpected delay at intersection(D_i), unexpected delay due to access road(D_{ar}), unexpected delay at mid-block due to pedestrian crossing(D_{pc}), unexpected delay at mid-block due to u-turning of vehicle(D_{ut}), unexpected delay at mid-block due to side friction(D_{sf}). Unexpected delay due to stopping at undefined curb stop(D_{ucs}) and unexpected delay at mid-block due to pedestrian crossing(D_{pc}) were found to be insignificant.So,final model was developed considering only significant variables. The R-square and adjusted R-square of final model obtained were 0.775 and 0.735 respectively.

Keywords

Travel time reliability, Public bus transport, Planning time, Multiple linear regression

1. Introduction

The public transportation system in the Kathmandu valley has been deteriorated over years due to various factors such as unplanned urbanization, rising motorization,lack of suitable transit infrastructure, escalating traffic congestion and reduced reliability.Commuters often endure long and frustrating journeys when using public transportation due to poor transport service. Many transport companies attempt to adhere to scheduled departure and arrival times but they frequently encounter significant obstacles such as heavy traffic, crashes incidents and other unforeseen events making it challenging to meet the expected reliability. The reliability of public transport systems is of great important to most public transport users as unreliability can lead to additional waiting time, arrivals either too early or too late at their destinations and missed connections. These disruptions can significantly increase passenger stress and discomfort [1].

The Asian Development Bank (ADB) and the Government of Nepal collaborated on the Kathmandu Sustainable Urban Transport Project (KSUTP), which aimed at ensuring sustainable, secure, and efficient Urban Transport Systems (SUTS) and thus strengthen the quality of urban life in the Kathmandu valley. Through implementing into action, four distinct components namely improving and modernizing public transportation, enhancing traffic management, strengthening walkability in the city centre and enhancing air quality monitoring's aimed to achieve its primary goal. KSUTP has chosen the Sinamangal-New Buspark route, which is approximately 9 km long, as its pilot route in order to improve reliability.

The issue of low reliability of public transportation in Nepal has drawn significant attention from public authorities, policy makers, planners and researchers. Efforts have been made to find the alternative solutions and more comprehensive framework for assessing the factors that affect the travel time reliability. Reliability in public transportation is considered as one of the most crucial aspects for evaluating the service quality, viewed from the perspective of passengers, operators, and the community.

The primary objective of this research work is to identify the major delays affecting travel time reliability of the public bus transportation services in Kathmandu Valley. Specifically, the study focuses on modelling the travel time reliability of public bus services with the Airport to Narayan Gopal Chowk Route serving as the selected case study route.

The identification of significant delays that contribute to the fluctuation in travel time reliability of the public transportation and development of predictive model, travel time reliability can provide valuation insights to planners and policy makers.

2. Literature Review

A number of studies have been done on travel time reliability of public bus transport like measuring of travel time reliability of public bus transport, operational assessment of public transport, empirical analysis for measuring travel time reliability, 95% travel time reliability of various public mode of transport, modelling of travel time, modelling of travel time reliability using risk assessment techniques. But there is limited study in modelling of travel time reliability incorporating mean travel time and different unexpected delay variables.

In order to determine how serious a delay will be on the busiest travel days, the Federal Highway Administration states that the simplest way to estimate travel time reliability is to look at the 90^{th} or 95^{th} percentile travel times for a certain route or trip. For commuters who are familiar with their routes, the 90^{th} or 95^{th} percentile journey times which are provided in minutes and seconds should be simple to understand [2]. Travel time reliability is defined by the Florida Department of Transportation as the percentage of travel time that takes no more than the anticipated amount of time plus an acceptable amount of extra unexpected time [3].

Aryal had carried out research on Nepal's requirement for public transport service. This study compared a number of variables in Kathmandu valley to determine the level of demand for public transportation. Five variables were taken into account in their choice-based conjoint experiment design: mode of transportation, waiting time, one-way fare per kilometer, commuting time per kilometer and manner of payment. Their research showed that the most common forms of transportation in Kathmandu are not favoured by the respondents. Their findings indicated the unsatisfied condition in which users felt about public transport [4].

Karami et al. had analyzed the features of the road network in Kota Bandar Lampung, Lampung, Sumatera, Indonesia, with regard to 95% travel time reliability. The characteristics of travel time reliability were measured using the buffer time method.To represent the impact of planning time and free-flow travel time on average journey time, they created a regression equation [5].

Saptarshi had done the study to determine the 95% travel time reliability of various public transportation modes along a specific route in the Kolkata city in India. The state government bus, private bus and minibus in-vehicle journey time reliability were estimated and then results were compared to metro railway.Their findings indicate that journey time reliability falls between 45 to 65 percent behind of the metro railway's reliability for all bus kinds. In order to provide valuable information on the bus reliability, characteristics including buffer time, buffer index, planning time, and planning time index were also calculated. The relationship between reliability and other important traffic measures like waiting time delays and congestion delays has also been investigated [6].

Ashwini did research on "Analyzing Travel Time Reliability of a Bus Route in a Limited Data Set Scenario : A Case Study" to analyze 95% travel time reliability.According to the National Urban Transport Policy, Government of India's Service Level Benchmarks for Urban Transport, headway, passenger waiting time, travel speed, and journey time are the reliability factors evaluated for public transportation service. Additionally,travel time reliability measures such the planning time index, travel time index, and buffer time index were evaluated. According to their findings, the public transport system faced an unexpected delay time of about 30% of the average travel time and more than twice as much free flow travel time needs to be scheduled during peak hour and worst case [7].

Elhenawy et al. has suggested modelling travel time with a combination of linear regressions.They used two normal components in the suggested model.The congested regime was modelled by the first component,while the free-flow regime was modelled by the second.Using a random forest machine-learning approach,the predictors utilized in the linear regression equation were chosen from the spatiotemporal speed matrix.The experimental results presented in this research demonstrated the model capacity to effectively anticipate travel time and capture its stochastic nature [8].

Using link flows that were observed in a road network,Uchida created a model for estimating the reliability of travel time that addresses travel demand and traffic capacity as causes of uncertainty. A model that estimates stochastic path flows using observed link flows had been developed to determine the unique travel time reliability [9].

Tu et al. has measured travel time reliability in a variety of methods and has identified it as one of the most important markers of the effectiveness of transportation systems.In this study, the two ideas of reliability are synthesized : traffic breakdown, which is a sign of travel time instability is considered as a risk, and travel time variability which is an indicator of journey time uncertainty, is considered as a consequence of this risk [10].

3. Methodology

3.1 Modelling of Travel Time Reliability

The objective of this study is to identify the major factors affecting the travel time reliability along the travel routes and develop a model that relates the planning time which is a measure of 95% travel time reliability of the route to these factors.Planning time (PT) refers to the travel time which is less than or equal to 95% of sample travel times and is the sum of mean travel time and buffer time as shown in equation 1.

$$PT = MTT + BT \tag{1}$$

Where,
PT : Planning Time
MTT : Mean Travel Time
BT : Buffer Time

The term mean travel time refers to the average travel time between origin to destination excluding the unexpected delays. Therefore, it is the sum of running time and expected stopped delay experienced by the vehicle. Buffer time refers to the unexpected delays or interruptions during the journey [11]. The different types of expected and unexpected delays are discussed in the following subsections :

3.2 Delay Type and Variables

The different types of delay and variables focused in this study are described as below :

3.2.1 Delay at Bus Stop

Delay at bus stop has been categorized into expected and unexpected delay as discussed below :

1. **Expected Delay at Bus Stop**
This delay refers to amount of time bus spends at a bus stop, either picking up or dropping off passengers before it resumes its route. According to a definition that is comparable,delay at bus stop has multiple elements that can be summed up as time wasted during stops for passengers to board and alight including the time spent for opening and closing bus doors [12]. Expected delays at bus stop are related to board and alight of individual passengers at designated bus stops only [6]. The expected delay at bus stop in this study is defined as the amount of time for picking and dropping of passengers including opening and closing of bus doors when bus heads in to the bus stop and when it reenters to the main traffic stream similar to that in Arhin . According to Arhin et al., this time for a single bus stop during morning and evening peak hours ranges between 49-51 secs.The study route consists of eight number of well designated bus stop.During free flow travel time at 6 : 00 AM in the morning,the average stop time at a single bus stop time was found to be 45.47 seconds which is near to value suggested by Arhin.Hence,the expected delay at a single bus stop in this study is assumed to be 50 secs according to Arhin [13].

2. **Unexpected Delay at Bus Stop** (D_{bs})
In the context of Nepal, there is a tendency for bus drivers to keep on waiting at bus stops to pick up more passenger. Therefore, the unexpected delay at bus stop (D_{bs}) in this study is defined as the time a bus spends in excess of 50 second in a designated bus stop.

3. **Unexpected Delay due to Stopping at Undefined Curb Stop** (D_{ucs})
Curb side bus stops use a marked portion of the through-traffic lanes for the boarding and alighting of passengers [14].The designated curb side bus stops in the study route lack specific markings. Unexpected delay due to stopping at undefined curb stop refers to picking and dropping passengers at the curb side area of the road [15] i.e., at locations lacking official bus stop signage. Thus, unexpected delay due to stopping at undefined curb stop in this study refers to the amount of time that a bus spends for alighting and boarding of passengers at the curb side of the road.

3.2.2 Delay at Intersection

Delay at intersection has been categorized as expected and unexpected delay as below :

1. **Expected Delay at Intersection**
In signalized intersections, a fixed number of approaches shares space alternatively for a pre-defined time interval as per the phasing scheme used [16]. Signal delay refers to the phenomenon where a vehicle stops within the designated "stop" line due to a signal, resulting in a delay in the travel time.The signal delay has been categorized as expected delay because it is a planned and predictable part of the traffic control system as well as drivers. Drivers know that they will have to wait for their turn when the signal is red for their direction, and this waiting time is part of the expected travel experience. Drivers, passengers and transportation planners take it into account when making travel decisions. Thus, signal delay in this thesis work refers to the amount of time that a bus spends at signalized intersection due to traffic signal, friction, high traffic volume, pedestrian crossing through zebra cross at that intersection as similarly defined by Sen [6].

2. **Unexpected Delay at Intersection** (D_i)
The delay at unsignalized intersection has been categorized as unexpected delay because it lacks predictable traffic signal cycle. The delay at unsignalized intersection is caused due to high traffic volume, pedestrian crossing without using zebra cross, u-turning of vehicle. Thus, the unexpected delay at intersection in this research work refers to the amount of time that a bus spends at unsignalized intersection due to due to high traffic volume, vehicle u-turning and pedestrian crossing without using zebra cross at that intersection.

3.2.3 Unexpected Delay at Access Road (D_{ar})

Unexpected delay at access road in this research work refers to the amount of time lost due to vehicles joining the main road from the access road in the same direction, right turning of vehicle from the access road to the main road, vehicle leaving the main road, right turning of vehicle from the main road to the access road as described by Boneson [17].

3.2.4 Delay at Mid-Block Section

1. **Unexpected Delay at Mid-Block due to Pedestrian Crossing** (D_{pc})
In Nepalese urban road sections, pedestrians frequently cross the road without using a zebra cross at the midblock part. In order to avoid conflict, pedestrians generally employ force gaps to cross the road and compel approaching vehicles to alter their path or apply their breaks. As stated by Golakiyaa, such pedestrian activity disrupts traffic flow and eventually causes delays in the movement of vehicles [18]. Thus, the unexpected delay at mid-block section due to pedestrian crossing in this study is defined as stopped delay of vehicle due to crossing of pedestrian without use of zebra cross [19].

2. **Unexpected Delay at Mid-Block due to U-Turning of Vehicle** (D_{ut})
The u-turning operation creates disturbance through vehicles in opposite direction.In most cases,it is observed that a larger radius is required for vehicles to u-turn which increases the delay [20]. The unexpected delay due to u-turning at mid-block sections in this research work refers to stopped delay of vehicles due to right turning of vehicle from opposite direction to change the direction of movement as similar described by Reid [21].

3. **Unexpected Delay at Mid-Block due to Side Friction (D_{sf})**
   Activities taking place on the sides of the road as well as inside the road itself are referred as side frictions because they obstruct the flow of traffic on the designated path [22]. Unexpected delay at mid-block due to side friction in this study is defined as the delays associated due to high traffic volume due to illegal parking at the road side,street vendors in the roadside and so on.During this time vehicle moves with very low speed almost like stopping [23].

3.3 Multiple Linear Regression

As discussed in sections 3.1 and 3.2, the buffer time is the function of unexpected delays.Therefore, the planning time is the function of mean travel time and unexpected delays in the route as shown in equation 2.

$$PT = MTT + D_{bs} + D_{ucs} + D_i + D_{ar} + D_{pc} + D_{ut} + D_{sf} \quad (2)$$

Where,
PT : Planning time
MTT : Mean travel time
D_{bs} : Unexpected delay at bus stop
D_{ucs} : Unexpected delay due to stopping at undefined curb stop
D_i : Unexpected delay at intersection
D_{ar} : Unexpected delay at access road
D_{pc} : Unexpected delay at mid-block due to pedestrian crossing
D_{ut} : Unexpected delay at mid-block due to u-turning of vehicles
D_{sf} : Unexpected Delay at Mid-Block due to side friction

Multiple linear regression was used to model the relationship between PT and the independent variables, mean travel time and different unexpected delays i.e., unexpected delay at bus stop (D_{bs}), unexpected delay due to stopping at undefined curb stop (D_{ucs}), unexpected delay at intersection (D_i), unexpected delay at access road (D_{ar}), unexpected delay at mid-block due to pedestrian crossing (D_{pc}), unexpected delay at mid-block due to u-turning of vehicle (D_{ut}), unexpected delay at mid-block due to side friction (D_{sf}) as discussed in previous section. So, planning time can be modeled as a linear function of MTT and unexpected delays as shown in equation 3.

$$PT = \beta_1 MTT + \beta_2 D_{bs} + \beta_3 D_{ucs} + \beta_4 D_i + \beta_5 D_{ar} + \beta_6 D_{pc} + \beta_7 D_{ut} + \beta_8 D_{sf} \quad (3)$$

Where,
β_1, β_2, β_3, β_4, β_5, β_6, β_7, β_8 represent coefficient to corresponding independent variables MTT, D_{bs}, D_{ucs}, D_i, D_{ar}, D_{pc}, D_{ut}, D_{sf} respectively.

3.4 Correlation Analysis

This analysis is used to check association between the two variables. It was used to measures the strength of the linear relationship between two independent variables. The high correlation between independent variables (Greater than 0.7) causes multi-collinearity which can cause issues in regression analysis.This is because it makes difficult to find out the particular effect of each independent variable on the dependent variable.

3.5 Study Area

The study area was selected such that buses of multiple bus service providers provide service to the passenger along this route. After preliminary study of site selection criteria, Airport to Narayan Gopal Chowk Route of 5.6 Kilometer (km) was selected for study area in this research work. The Airport to Narayan Gopal Chowk Road consists of eight bus stops, four unsignalized intersection at Gaushala Chowk, Bageshwari Chowk, Chabahil Chowk and Dhumbarahi Chowk.The study route consist of one signalized intersection at Mitra Park Chowk where buses of different bus service providers provide their service to the customers. Mahanagar Yatayat, Mahasagar Yatayat, Mayur Yatayat and Khwopa Yatayat were selected for the study purpose.The study area's overview is shown in Figure 1.

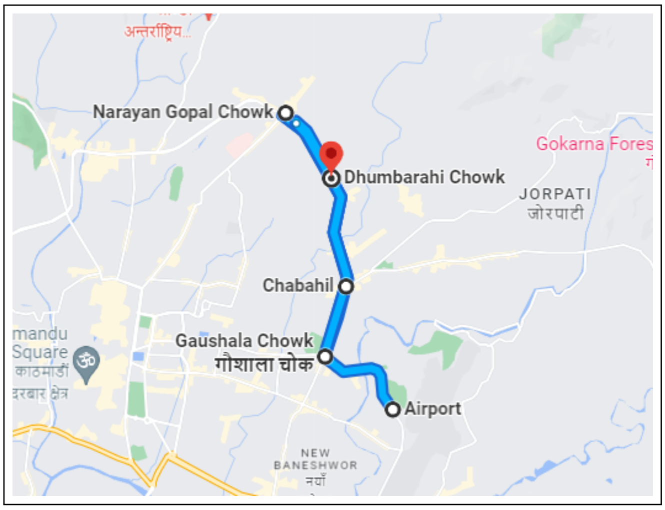

Figure 1: Study Area

3.6 Data Collection

On board technique was adopted to collect the data.Due to infeasibility of data collection by a single person,enumerators (Civil Sub-Engineers and Civil Engineering Students) were hired. Using a stopwatch, the enumerators recorded the travel time and delay by travelling on the study route in a bus. Enumerators were trained to collect the data by boarding and giving instructions about different types of delay of selected bus service providers of selected study route at first.

Then,enumerators were able to collect data. Time of the beginning of the journey in hour,minute and second at the origin was noted.The different types of delays data were recorded using stopwatch in minute and second by each enumerator during the journey time in each journey.The end time was noted down at the destination in hour,minute and second.The same process was followed in the reverse direction too.From this,the travel time taken by the buses of Mahanagar Yatayat, Mahasagar Yatayat, Mayur Yatayat and Khwopa Yatayat of Airport to Narayan Gopal Chowk Road were obtained.The data were collected from 8 : 30-11 : 30 AM for six days during morning peak hour.

3.7 Data Extraction

The data obtained were input on spreadsheet for further processing. The data were classified per 30 min interval of time i.e., 8 : 30-9 : 00 AM and so on for each bus service providers. For calculating 95% Travel time reliability, mean travel time and average delay, seven data of same time interval for each bus service provider were grouped together.The planning time was calculated for 95% travel time reliability as a 95 percentile for a group of seven number of data.Similarly,the mean travel time and the delay time were calculated for a group of seven number of data.In this research work,one set of data was made from seven number of data of same time interval.Thus, forty-one set of data were made from more than 290 samples of data in total for modelling travel time reliability.

3.8 Sample Size

The rule of thumb has suggested to use ten to twenty cases for each independent variable. Green (1991) has proposed two variations for consideration of dependent variable in multiple linear regression. He has proposed minimum sample size to be greater or equal to fifty plus eight times number of independent variables [24]. The sampling has been done based upon these two criteria. This research work consists of eight independent variables so that, sampling size was taken maximum of twenty times independent variable and fifty plus eight times number of independent variables which is about 160.For this case, more than 290 samples were taken in total for selected bus service providers.

4. Result and Discussion

4.1 Descriptive Statistics

The descriptive statistics reveal that the mean delay time of unexpected delay at bus stop (D_{bs}) is 0.648 minutes with standard deviation 0.495 minutes,unexpected delay due to stopping at undefined curb stop (D_{ucs}) is 2.182 minutes with standard deviation 0.483 minutes, unexpected delay at intersection (D_i) is 1.198 minutes with standard deviation 0.803 , unexpected delay at access road (D_{ar}) is 0.646 minutes with standard deviation 0.364 minutes, unexpected delay at mid-block due to pedestrian crossing (D_{pc}) is 0.208 minutes with standard deviation 0.125 minutes , unexpected delay at mid-block due to u-turning of vehicle (D_{ut}) is 0.182 minutes with standard deviation 0.142 and unexpected delay at mid-block due to side friction (D_{sf}) is 1.877 minutes with standard deviation 0.895 as shown in the Table 1.The independent delay variable with maximum value of delay time is unexpected delay due to stopping at undefined curb stop (D_{ucs}) with delay value of 2.182 minutes and independent delay variable with minimum value of delay time is unexpected delay at mid-block due to u-turning of vehicle at mid block section (D_{ut}) with delay value of 0.182 minutes.

Table 1: Descriptive Statistics

Variables	Mean Delay Time (Min)	Std. Deviation (Min)
D_{bs}	0.648	0.495
D_{ucs}	2.182	0.483
D_i	1.198	0.803
D_{ar}	0.646	0.364
D_{pc}	0.208	0.125
D_{ut}	0.182	0.142
D_{sf}	1.877	0.895

4.2 Correlation Analysis

Both independent and dependent variables were entered into SPSS in order to conduct a correlation study.The dependent variable is planning time and the independent variable are mean travel time (MTT) and different unexpected delays i.e., unexpected delay at bus stop (D_{bs}),unexpected delay due to stopping at undefined curb stop (D_{ucs}),unexpected delay at intersection (D_i), unexpected delay at access road (D_{ar}), unexpected delay at mid-block due to pedestrian crossing (D_{pc}), unexpected delay at mid-block due to u-turning of vehicle (D_{ut}), unexpected delay at mid-block due to side friction (D_{sf}).The correlation analysis shows that the maximum correlation value is 0.340 between unexpected delay at mid-block due to u-turning of vehicle (D_{ut}) and unexpected delay at mid-block due to pedestrian crossing (D_{pc}) which is less than 0.7.So, all independent variables mean travel time (MTT) and different unexpected delays variables i.e., unexpected delay at bus stop (D_{bs}),unexpected delay due to stopping at undefined curb stop (D_{ucs}), unexpected delay at intersection (D_i), unexpected delay at access road (D_{ar}), unexpected delay at mid-block due to pedestrian crossing (D_{pc}), unexpected delay at mid-block due to u-turning of vehicle (D_{ut}), unexpected delay at mid-block due to side friction (D_{sf}) were considered for model development.

4.3 Model Development

The model was developed by adopting the stepwise regression method for multiple linear regression analysis.The best model with more number of significant delay variables was selected.Unexpected delay due to stopping at undefined curb stop (D_{ucs}) and unexpected delay at mid-block due to pedestrian crossing (D_{pc}) were found to be insignificant.So,significant variables were taken into account when developing the final model i.e.unexpected delay at bus stop (D_{bs}), unexpected delay at intersection (D_i), unexpected delay at access road (D_{ar}), unexpected delay at mid-block due to u-turning of vehicle (D_{ut}), unexpected delay at mid-block due to side friction (D_{sf}). The R^2 and adjusted R^2 of final model obtained were 0.775 and 0.735 respectively as given in Table 2 which indicates that 77.5% variation in planning time is explained by independent variables.

Table 2: Model Summary

Model	R	R Square	Adjusted R Square
1	0.880	0.775	0.735

The coefficient of the final model obtained is shown in Table

3.From this,it can be concluded that each independent variables have significant relation with planning time.

Table 3: Coeffcient of Final Model

Variables	Coeffcients (B)	Std.Error	t	p-value
MTT	0.817	0.163	5.003	0.000
D_{bs}	2.099	0.945	2.220	0.033
D_i	2.613	0.561	4.655	0.000
D_{ar}	3.012	1.212	2.485	0.018
D_{ut}	6.818	3.309	2.061	0.047
D_{sf}	1.780	0.522	3.408	0.002

Mean travel time (MTT) and unexpected delay at intersection (D_i) were found to be most significant independent variables affecting planning time. Unexpected delay at bus stop (D_{bs}) increases planning time by 2.099 min. Unexpected delay at intersection (D_i) increases planning time by 2.613 min. Unexpected delay at access road (D_{ar}) increases planning time by 3.012 min. unexpected delay at mid-block due to u-turning of vehicle (D_{ut}) increases planning time by 6.818 min. unexpected delay at mid-block due to side friction (D_{sf}) increases planning time by 1.780min. The equation for the final model of planning time of public bus transport can be seen in equation 4 with significant independent variables mean travel time (MTT), unexpected delay at bus stop (D_{bs}), unexpected delay at intersection (D_i), unexpected delay at access road (D_{ar}), unexpected delay at mid-block due to right turning of vehicle (D_{ut}), unexpected delay at mid-block due to side friction (D_{sf}).

$$PT(min) = 0.817 \times MTT + 2.099 \times D_{bs} + 2.613 \times D_i + 3.012 \times D_{ar} + 6.818 \times D_{ut} + 1.780 \times D_{sf} \quad (4)$$

with $R^2 = 0.775$ and Adjusted $R^2 = 0.735$

5. Conclusion and Recommendation

5.1 Conclusion

95 % travel time reliability has been considered for calculating planning time because 95% travel time reliability is the standard travel time reliability followed by Federal Highway Administration.So, in this research work 95% travel time reliability has been adopted.The correlation analysis has showed the weak relationship between the variables.So, all independent variables mean travel time (MTT) and different unexpected delays variables i.e., unexpected delay at bus stop (D_{bs}),unexpected delay due to stopping at undefined curb stop (D_{ucs}), unexpected delay at intersection (D_i), unexpected delay at access road (D_{ar}), , unexpected delay at mid-block due to pedestrian crossing (D_{pc}), unexpected delay at mid-block due to u-turning of vehicle (D_{ut}), unexpected delay at mid-block due to side friction (D_{sf}) were considered for model development.

The Multiple linear regression analysis technique was adopted to model the travel time reliability in SPSS.Unexpected delay due to stopping at undefined curb stop (D_{ucs}) and unexpected delay at mid-block due to pedestrian crossing (D_{pc}) were found to be insignificant.The significant variables were found to be mean travel time (MTT), unexpected delay at bus stop (D_{bs}), unexpected delay at intersection (D_i), unexpected delay at access road (D_{ar}), unexpected delay at mid-block due to u-turning of vehicle (D_{ut}), unexpected delay at mid-block due to side friction (D_{sf}).The R^2 and adjusted R^2 of final model obtained were 0.775 and 0.735 respectively.

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