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Travel Time and Delay Study to Improve Public Transit Systems in Jordan

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Abstract

Transportation is essential for any nation's development and growth. Transportation has played a significant role by facilitating trade, commerce, and social interaction, while consuming a considerable portion of time and resources. Many organizations and agencies exist to plan, design, build, operate, and maintain transportation systems. The movements of people and goods, which is the basis of transportation, has always been undertaken to accomplish those basic objectives or tasks that require transfer from one location to another. Every day, millions of people leave their homes and travel to a workplace, office, classroom, or distant city. Public transit system is one of the most important among transportation systems.

This research paper presents a travel time and delay study on the public transit system inside Amman area in Jordan. Amman–Sweileh line is a busy, essential, and vital line connecting major areas inside Amman. The main importance of this study is to convince and attract the public to use the public transit system for travel instead of using their private cars. If that can be achieved, many advantages can be attained. By using the public transit system instead of using private cars, the following advantages can be attained: reducing the congestion on the road network especially during peak hours, reducing the cost of traveling for the public, increasing the efficiency of the road network, increasing safety, reducing the maintenance cost of the roads, improving traffic flow and traffic operations, and reducing air pollution and preserving the environment.

The main objective of this study is to improve the public transit system in Jordan. That can be done through making a comparison between the travel time by using the public transit system and by using private cars. Also, to study the delay due to using the public transit system, and study the variables affecting this delay to find the best solution to minimize this delay in order to reduce the trip travel time to minimum value. It was found that there is a major difference in travel time between using the public transit system and using the private car. Also, it was found that the main variables that affect the trip travel time are: The total delay time due to stopping to pickup and discharge passengers and due to stopping at fixed interruptions, the bus model, and the bus size.

Delay and travel time can be reduced to a practical and reasonable value by decreasing the number of times that the bus stops for pickup and discharging the passengers, using small buses, and by using newer, faster models of buses. There must be a continuous improvement on the public transit systems in order to be able to attract and convince more people to use it. Finally, it is hoped that in the near future there will be more practical and efficient public transit systems in Jordan.

Key Words: Air Pollution, Environment, Travel Time, Running Time, Delay, Public Transit System, Intelligent Transportation System ITS, Pickup and Discharge of Passengers, Traffic Operations, Amman, Sweileh, Jordan.

1. Introduction

Transportation is essential for any nation's development and growth. Transportation has played a significant role by facilitating trade, commerce, and social interaction, while consuming a considerable portion of time and resources. Many organizations and agencies exist to plan, design, build, operate, and maintain transportation systems. The movements of people and goods, which is the basis of transportation, has always been undertaken to accomplish those basic objectives or tasks that require transfer from one location to another. Every day, millions of people leave their homes and travel to a workplace, office, classroom, or distant city. Public transit system is one of the most important among transportation systems (Garber 2010).

A travel time study determines the amount of time required to travel from one point to another on a given route. In conducting such a study, information may also be collected on the locations, durations, and causes of delays. When this is done, the study is known as a travel time and delay study. Data obtained from travel time and delay studies give a good indication of the level of service on the study section. These data also aid the traffic engineer in identifying problem locations, which may require special attention in order to improve the overall flow of traffic on the route (Garber 2010).

1.1 Applications of Travel Time and Delay Data

The data obtained from travel time and delay studies may be used in any one of the following traffic engineering tasks (Garber 2010):

• Determination of the efficiency of a route with respect to its ability to carry traffic

• Identification of locations with relatively high delays and the causes for those delays

• Performance of before-and-after studies to evaluate the effectiveness of traffic operation improvements

• Determination of relative efficiency of a route by developing sufficiency ratings or congestion indices

• Determination of travel times on specific links for use in trip assignment models

• Compilation of travel time data that may be used in trend studies to evaluate the changes in efficiency and level of service with time

• Performance of economic studies in the evaluation of traffic operation alternatives that reduce travel time

1.2 Definition of Terms Related to Travel Time and Delay Studies

The following are terms commonly used in travel time and delay studies (Garber 2010):

1. Travel time is the time taken by a vehicle to traverse a given section of a highway.

2. Running time is the time a vehicle is actually in motion while traversing a given section of a highway.

3. Delay is the time lost by a vehicle due to causes beyond the control of the driver.

4. Operational delay is that part of the delay caused by the impedance of other traffic.

5. Stopped-time delay is that part of the delay during which the vehicle is at rest. In this delay study it is called total time delay which includes fixed delay and delay due to stopping for pick up and discharge of passengers.

6. Fixed delay is that part of the delay caused by control devices such as traffic signals. This delay occurs regardless of the traffic volume or the impedance that may exist.

7. Travel-time delay is the difference between the actual travel time and the ideal travel time assuming that a vehicle traverses the study section at the posted speed limit.

1.3 Methods for Conducting Travel Time and Delay Studies

Several methods have been used to conduct travel time and delay studies. These methods can be grouped into two general categories: (1) those using a test vehicle and (2) those not requiring a test vehicle. The particular technique used for any specific study depends on the reason for conducting the study and the available personnel and equipment (Garber 2010).

1.3.1 Methods Requiring a Test Vehicle

This category involves three possible techniques: floating-car, average-speed, and moving-vehicle techniques (Garber 2010).

1.3.2 Methods Not Requiring a Test Vehicle

This category includes the license-plate method and the interview method (Garber 2010).

1.3.3 Intelligent Transportation System ITS Advanced Technologies

ITS, which is also referred to as Telematics, generally can be described as the process through which data on the movement of people and goods can be collected, stored, analyzed, and related information disseminated. The process has been used in many areas of transportation engineering including the management of traffic, public transportation, traveler information, electronic toll payment, and safety. The onset of ITS has facilitated the development of advanced technologies to support the system. The use of cell phones to collect travel times on roadways is one such technology. A commonly used technology for locating the positions of the cell phones is the GPS satellite system. This system can locate the position of a cell phone with an accuracy of between 15 and 90 ft. By probing cell phones on highways, the technology is used to determine average speeds and travel times along highways. Another method used to obtain the locations of cell phones is triangulation, which uses the computed distances of the cell phone from three nearby stations to obtain its position (Garber 2010).

1.4 Literature Review

There are many studies which were done in the United States (USA) and world wide on the public transit system. Most of the research and studies were published in the Transportation Research Record (TRR) Journal

(TRB 2013). The Highway Capacity Manual (HCM) is a publication of the Transportation Research Board (TRB) of the National Academies of Science in the United States. It contains concepts, guidelines, and computational procedures for computing the capacity and quality of service of various highway facilities, including freeways, highways, arterial roads, roundabouts, signalized and unsignalized intersections, rural highways, and the effects of mass transit, pedestrians, and bicycles on the performance of these systems (Wikipedia 2013).

The Highway Capacity Manual (HCM) (HCM 2010) contains guidelines and procedure for estimating transit capacity. It defines basic capacity concepts and principles; summarizes previous studies; develops analytic relationship; presents capacity guidelines; and sets forth illustrative applications. The guidelines and procedure may be used to estimate:

1- The effects of bus flows on freeway and signalized intersection capacity.
2- Total passenger or person flow based on roadway operation conditions, and the prevailing mix of cars and buses.
3- Generalized ranges of bus capacities for arterial streets, downtown streets, and bus ways.
4- Bus birth (stop) requirements at terminals and along downtown bus ways, bus only streets, and other city streets.

Also, the HCM provides ways to address various questions normally encountered in transit service planning and operations. For instance:

1- How many passengers can be carried per unit time?
2- How many transit vehicles are needed to provide a specific rate of passenger flow?
3- How many passengers can be carried with a given vehicle fleet?

Transport system management solutions to urban transport problems have increased the interest in the person capacity characteristics of transportation facilities. The underlying rationale is that although buses require more street space per vehicle than private cars, they carry many more passengers per vehicle than private cars, especially during peak hours. Thus public transportation emerges as an important way to increase the number of people carried by urban transportation system. Transit vehicles carry a substantial number and proportion of peak hour person trips to and from the downtown streets (HCM 2010).

Each roadway or transit facility should be analyzed in terms of the number of people it carries in a specific time period. This calls for knowing both the number and occupancies of each type of vehicle. The person-capacity or passenger-carrying capability for any given transport route can be defined as the maximum number of people that can be carried past a given location during a given time period under specified operation conditions without unreasonable certainty. The passenger capacity of a transit line is the product of the number of vehicles per hour and the number of passengers that each vehicle can carry (HCM 2010).

Four basic factors determine the maximum passenger capacity:

1- The maximum number of vehicle per transit unit.
2- The passenger capacity of the individual transit vehicle.
3- The minimum possible headway or time spacing between individual vehicles.
4- The number of movement channels or loading positions.

The concept of level of service (LOS) for transit is far more complex than for highways. It includes such factors as coverage of major residential and activity areas, comfort, speed, and reliability. Also, convenient schedules, comfortable vehicle, and frequent, fast, and reliable service contribute to LOS. Speed is influenced not only by the number of riders using a transit line, but to an even greater extent by stop frequency and dwell times, traffic interference, and right of way design. Productive capacity, the product of passenger capacity and speed, is an important measure of transport system efficiency. It is important in that it distinguishes between equal passenger throughputs achieved at different speeds. In general, productive capacity will be influenced by the type of technology, the method of operation (private right-of-way versus shared), and the spacing of stops. Two aspects of LOS are important from a capacity perspective: the number of passengers per vehicle, and the number of vehicles per hour. Capacity related LOS criteria should reflect both. Also, in HCM there is a section which presents transit capacity experience. It Identifies service frequencies, passenger carried, and passenger car equivalents, and it indicates the ranges in capacity based on this experience. The passenger service times and dwell times at bus stops are necessary for estimating bus and passenger capacities and the capacity increases that would result from changes in equipment or operating practice. A passenger service time, which is the amount of time required by each boarding or alighting passenger, depends on many factors; these include (HCM 2010):

1- Number and width of doors used.

2- Number and height of steps.
3- Type of door and actuation control.
4- Fare collection system.
5- Amount of baggage or parcel carried by passenger.
6- Seating configuration.
7- Aisle width.
8- The mix of alighting versus boarding.
9- The condition and configuration of the pavement, curb, and stop area.

Dwell time at bus stops, which is the amount of time that buses spend at specific stops, reflects the time of day, location of stops, surrounding land uses, and the number of interchanging transit lines. Each bus requires a certain amount of service time at stops that varies with the number of boarding and alighting passengers, door configuration of buses, and method of fare collection (HCM 2010).

2. Problem Definition

Traveling from one place to another is very essential in our modern life. There are many ways to travel, called traveling modes. There are five main traveling modes choice alternatives available to commuters. These modes are:

1- Private car
2- Carpool
3- Bus and public transit
4- Service
5- Taxi cap

The most important of public transit system modes is buses. Our concern in this study will be buses. The choice of a certain mode depends mainly on (Garber 2010, Papacostas 2008, and Al-Omar 1994):

1- Car ownership
2- Trip importance
3- Trip purpose
4- Mode cost
5- Trip travel time
6- Mode comfort
7- Mode safety

Trips can be classified according to its purpose as (Garber 2010, Papacostas 2008):

1- Work trips
2- Shopping trips
3- Recreation trips
4- Social trips
5- School trips

The most crucial of the above is work trips. Work trips are considered as the largest generator for trips in urban areas. Work trips are considered as the main cause of traffic problems especially during the peak hours. There are two portions of people in the case of car ownership; people who own private cars and people who do not own any. People who do not own a car are forced to use the public transit system or any other mode rather than using the private car. On the other hand, people who own private cars will either use their cars in their trips or use any other mode listed above. There are many people who use their own cars in traveling from one place to another instead of using the public transit system.

This travel time and delay study will focus on the delay and the variables affecting it. This study was done for Amman-Sweileh line. Amman–Sweileh line is a busy, essential, and vital line connecting major areas inside Amman Area in Jordan.

3. Study Significance

The main significance of this delay study is :

1- Improving the public transit system.
2- Attracting and convincing the public to use the public transit system instead of their private cars. And if this was achieved it would lead to the following advantages:
   a- Reducing the number of vehicles using road network.
   b- Reducing the cost of transportation for the public

c- Increasing the efficiency of the road network.
d- Improving traffic operations and traffic flow.
e- Increasing safety
f- Reducing air pollution.

4. Study Objectives

The main objectives of this study are:

1- To improve the public transit system in Jordan

2- To make a comparison between the travel time by using the public transit system and by using private cars.

3- To study the delay due to using the public transit system, and study the variables affecting this delay to find the best solution to minimize this delay in order to reduce the trip travel time to minimum value.

4- To recommend some solutions to improve the public transit system in Jordan

5. Data Collection and Methodology

Data was collected for Amman-Sweileh line by using the public transit system and by using the private car. The collection of data was taken at the peak hours, the morning peak from 7:30 AM to 8:30 AM, and the afternoon peak from 3:00 PM to 4:00 PM. Data collection was on different days mainly on Mondays, Tuesdays and Wednesdays. Amman-Sweileh line was chosen as a representative of other major lines because it is a busy and a very essential line connecting major areas inside Amman. The trip distance from Amman to Sweileh was measured and it is 10.65 km. Amman-Sweileh line is an interrupted line which consists of 3 intersections with 1 traffic signal and 2 roundabouts. This line begins from Sweileh roundabout and ends at Abdaly terminal. On Amman-Sweileh line there are 26 buses, 24 of them are small and 2 buses are big. The data was collected for the two trip directions, from Amman to Sweileh and from Sweileh to Amman. For each direction, the data of 16 trips was collected using the public transit system, therefore the total number of trips was 32 trips. On the other hand, the data of 5 trips was collected by using the private car for each direction; therefore the total number of trips was 10 trips.

For each trip by using the public transit system, the following data was collected and measured:

1- The waiting time for the bus.
2- The travel time
3- The running time
4- Total delay time
5- Total number of stopping for pickup and discharge of passengers
6- Delay time due to stopping for pickup and discharge of passengers
7- Delay time due to stopping at fixed interruptions such as traffic signals and roundabouts.
8- Number of stopping at fixed interruptions
9- Bus size
10- Bus model
11- Trip direction

All these data are summarized and shown in Table 1. Also, simple statistics for these data are shown in Table 2. On the other hand, for each trip by using the private car the following data was collected and measured:

1- The travel time
2- The running time
3- Delay time due to stopping at fixed interruptions

All these data are summarized and shown in table 3. Also, simple statistics for these data are shown in Table 4.

The different variables were labeled as follows:

Y1 = Travel Time in minutes.

Y2 = Running time in minutes.

X1 = Number of stopping for pickup and discharge of passengers.

X2= Bus model: 1 for new models, 0 for old models.

X3= Bus size: 1 for small buses, 0 for big buses.

X4= Total delay time in minutes.

X5= Delay time for pickup and discharge of passengers in minutes.

X6= Delay time at fixed interruptions in minutes.

X7= Number of stopping at fixed interruptions.

X8= Trip direction: 1 for Amman to Sweileh, 0 for Sweileh to Amman.

X9= Waiting time in minutes.

6. Data Calculation and Model Formulation

6.1 Data calculations

Sample calculations for trips by using the public transit system:

For trip number 1 as shown in table 1

1- Travel time = 15 min.
2- Running time = travel time – total delay time = 15 – 1.92=13.08 min.
3- Total delay time = 1.0 +0.92 = 1.92 min.

All calculations and results are shown in Table 1. Also, sample calculations for trips by using the private car: For trip number 1 as shown in Table 3.

1- Travel time = 13.25 min.
2- Running time = 13.25 – 1.48 = 11.77 min.

All calculations and results are shown in Table 3. Also, simple statistics for trips by using the public transit system are shown in Table 2. Sample calculations for some items are as follows:

1- Mean value for the travel time = 648/32 = 20.25 min.
2- Standard deviation for the travel time = 2.61509 min.

Also, simple statistics for trips by using the private car are shown in Table 4.

6.2 Statistical Model Formation

To find the relationship between different variables, regression analysis was used. Regression analysis is a statistical technique for modeling and investigating the relationship between two or more variables (Abojaradeh 2013, Abojaradeh 2012, Montgomery 2010).

SPSS (Statistical Package for Social Sciences) software was used in forming the Regression Models in this study. SPSS is considered one of the most frequently used program for researchers in many fields such as engineering, science, art, education, and psychology (SPSS 2009).

The method of least squares that leads to the best fitting line of a postulated form to a set of data is used to form Regression Models between the dependent variable Yi, and independent variables Xi. In this study, the dependent variable Yi includes travel time and running time. On the other hand, the independent variable Xi includes the variables affecting the travel time. A relationship between the dependent and the independent variables of the form

$$\boxed{Y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_n X_n}$$

It was calibrated by the method of least squares. This relationship is known as a multiple linear regression model.

6.3 Interpretation and Selection of the Best Regression Model

Stepwise calibration procedure was used to form the Multiple Linear Regression Model. The selections of explanatory variables follow the following four guidelines to decide which explanatory (independent) variables to include in the linear regression model. The selected independent variable has to follow the following four rules:

1. Must be linearly related to the dependent variable.
2. Must be highly correlated with the dependent variable.
3. Must not be highly correlated between themselves.
4. Must lend themselves to relatively easy projection.

The selected regression model has to have a maximum of 3 to 4 variables in order to have an easy projection and application, and in order to have a lower cost. Also, the selected regression model should have strong coefficient of determination R^2 value (Abojaradeh 2013, Abojaradeh 2012, Montgomery 2010).

The coefficient of determination R^2, quantifies the fact that the goodness of fit of a regression line increases with the proportion of the total variation that is explained by the regression line. R^2 ranges from zero, when none of the total variation is explained by the regression line, to unity when all of the variation is explained by the line. It is denoted as a squared quantity to capture the fact that it is always non negative. The square root of R^2 is the Coefficient of determination, and it is called the coefficient of correlation (r or R). Its value can range from -1 to 1. In the case of linear regression, the sign of R is the same as the sign of the slope of the regression line. When R is near 1, there is a high positive correlation between x and y. when R is near -1, there is a high negative correlation. If R is around zero, then there is no correlation between x and y (Abojaradeh 2013, Papacostas 2008).

6.4 Statistical Models

All multiple regression models are as follows:

The General Linear procedure in SPSS was done for the following:

1- Model between travel time Y1 as dependent variable, and independent variables X1, X2, and X3.

$$Y1 = 20.895 + 0.28X1 – 1.901\ X2 – 0.481X3 \qquad R^2 = 0.663$$

2- Model between running time Y2 as dependent variable, and independent variables X1, X2, and X3

$$Y2 = 20.208 – 0.09X1 – 1.977X2 – 2.714X3 \qquad R^2 = 0.564$$

3- Model between total delay time X4 as dependent variable, and independent variables X1, X2, and X3

$$X4 = 0.764 + 0.258X1 + 0.05X2 – 2.714X3 \qquad R^2 = 0.752$$

Also, by using the selection of variables in multiple regression to find the best variables to inter the model, Stepwise Regression Procedure was used for this purpose. Summary for the best multiple regression models are as follows:

1- Model between Y1 and X1, X2, X3, X4, X5, X6, X7, and X8:

$$Y1 = 19.967 – 1.905X2 – 2.692X3 + 0.970X4 \qquad R^2 = 0.772$$

2- Model between Y2 and X1, X2, X3, X4, X5, X6, X7, and X8:

$$Y2=19.921 – 1.908X2 – 2.757\ X3 \qquad R^2 = 0.561$$

3- Model between X4 and X1, X2, X3, X4, X5, X6, X7, and X8:

$$X4= 0.007 – 0.005X2 – 0.004X3 + 1.0\ X5 + 0.998X6 \qquad R^2 = 1.0$$

7. Results and Analysis

1. The mean value of the travel time by using the bus = 20.25 min. While the mean value of the travel time by using the private car = 13.28 min. It is clear that there is a significant difference between the two travel times.
The difference = 20.25 – 13.28 = 6.97 min.
% difference = 6.97 / 13.28 = 52.5%
By adding the mean waiting time, which is 7.875 min, to the mean travel time by using the bus, the total time will be 20.25 + 7.875 = 28.125 min.
The new difference is 28.125 – 13.28 = 14.845 min.
The new % difference = 14.845 / 13.28 = 111.8%.
The new difference is significantly high.
2. The mean value of the running time by using the bus is 16.4 min, while the mean value of running time by using the private car is 12.16 min.
The difference = 16.4 – 12.16 = 4.24 min.
% difference = 4.24 / 12.16 = 34.9%
It is clear that the difference between the two running times is great, but not as much as the difference between the two travel times.
By adding the mean waiting time which is 7.875 min to the mean running time by using the bus, the total time will be = 16.4 + 7.875 = 24.275 min.
The difference = 24.275 – 12.16 = 12.12 min.
% difference = 12.12/12.16 = 100%
By adding the mean waiting time for the bus to the mean travel time and the mean running time, the percentage difference is significantly high.
3. The difference between travel time by using the bus, and the travel time by using the private car can be reduced to a minimum value if the travel time by using the bus is reduced to a minimum value. This can be done by the following:
a. Reducing the number of stops for pick up and discharge of passengers to a minimum value.
b. Using new models of buses.

c. Using smaller buses
d. Increasing the number of buses to reduce the waiting time.

For example, by using the resulted model between travel time and X1, X2, and X3, the value of travel time can be predicted for the new values of X1, X2, and X3. For example for X1 = 0, X2 = 1, X3 = 1

$Y1 = 20.90 + 0.24X1 – 1.9X2 – 3.48X3$, $Y1 = 15.52$ min.

By comparing this value of the travel time with the mean value which is = 20.25 min, it is clear that the new value is much less than the mean travel time, and the new value is an acceptable one in comparison with the value of the mean travel time by using the private car, which is 13.28 min. The new difference = 15.52 – 13.28 = 2.24 min. But, in reality X1, which is the number of stops for pick up and discharge of passengers, can not be equal to 0. By using a reasonable value for X1, and substituting it in the equation of Y1, a new predicted value for travel time can be obtained. For example, for X1= 10 and X2= 1 and X3= 1, Y1 = 17.92 min.

The new difference = 17.92 – 13.28 = 4.64 min. This is still not a very large value.

Also, this analysis can be applied on the other models for the predictions of new values of travel time and running time and total delay time. The predicted values will depend on the values of the other variables in the model.

4. The travel speed of the bus and the private car can be calculated as follows:
Average travel speed = Distance / Average travel time.
Average travel speed = 10.65 km / 20.25 min = 31.6 km/h, and for the private car.
Average travel speed = 10.65 km / 13.28 min = 48.1 km/h
It is clear that there is a significant difference between the two travel speeds and that is due to the difference in travel time. Also, the average running speed can be calculated as follows:
Average Running Speed = Distance / Average running time.
For the bus: Average Running Speed = 10.65 km / 16.4 min = 39.0 km/h
And for the private car: Average Running Speed = 10.65 km/ 12.16 min = 52.5 km/h
It is clear that the difference in the average running speed is high. The difference in average travel speed and average running speed between using the bus and the private car can be reduced to a minimum value by the following:
a- Reducing the number of stops for pick up and discharge of passengers to a minimum value.
b- Using new models of buses.
c- Using small buses.
d- Increasing the number of buses to reduce the waiting time.
By reducing the number of stops and using newer models of buses and smaller buses there will be a significant increase in the running and travel speed. That means a reduction in delay time and in the travel time due to using the public transit system.

5. From the correlation between the variables as shown in Table 5, the following results are obtained:
a- Travel time is most highly correlated with the total delay time X4, and then with the number of stops for pick up and discharge, and then with the bus model X2. On the other hand, the travel time is not correlated with the trip direction X8, which means the trip direction has no effect on travel time.
b- Running time Y2 is more highly correlated with the bus size X3 than with the bus model X2. On the other hand, running time is not correlated with X5 and X1.
c- Total delay time X4 is most highly correlated with delay time due to stopping for pick up and discharge of passengers X5, then with the number of stops for pickup and discharge of passengers X1, then with delay time at fixed interruptions X6. On the other hand X4 is not correlated with X3.
6. In spite of high correlation between travel time and number of stops for pickup and discharge of passengers X1, X1 did not appear in the regression model of Y1 and the other variables X1, X2, X3, X4, X5, X6, X7, X8. That is because the total delay time X4 and X1 are highly correlated to each other and X4 is more correlated with Y1, so that only one of the two will appear in the model which is X4.
7. From R square procedure output, the following results can be obtained:
a- For the model between Y1 and X1, X2, X3, X4, X5, X6, X7, X8:
The best one variable model is with X4.
The best two variable model is with X3, and X4.
The best three variable model is with X2, X3 and X4.
b- For the model between Y2 and X1, X2, X3, X4, X5, X6, X7, X8:
The best one variable is with X3.

The best two variable model is with X2, and X3.
The best three variable model is with X2, X3 and X7.
c- For the model between X4 and X1, X2, X3, X5, X6, X7, X8:
The best one variable is with X5.
The best two variable model is with X5, and X6.
The best three variable model is with X2, X5 and X6.

8. Conclusions

1- There is a significant difference between travel time by using the public transit system and by using the private car on Amman-Sweileh line.
2- The travel time by using the public transit system depend mainly on:
   a- The total delay time.
   b- The number of stopping for pickup and discharge of passengers.
   c- The model of the bus.
   d- The size of the bus.
3- Total delay time depends mainly on :
   a- Number of stopping for pick up and discharge of passengers.
   b- The model of the bus.
   c- The size of the bus.
4- The travel time is not affected by trip direction.
5- The waiting time for the public transit bus on Amman-Sweileh line is not too high value. It can be reduced by the following :
   a- Increasing the number of buses serving on the line; especially during the peak hours.
   b- Reducing the trip travel time.
   c- Reducing the total delay time.
6- It is clear that delay problems occur at peak hours, this situation can be solved by the spreading of peak period demand through the implementation of staggered work schedules.
7- The total delay time due to using the public transit system can be reduced by the following:
   a- Reducing the number of stopping for pickup and discharge of passengers.
   b- Using new model of buses.
   c- Using small size buses.
8- The difference between the travel time by using the public transit system and by using the private car can be reduced by reducing the travel time by using a public transit system, which can be done by reducing the total delay time to minimum value.
9- By reducing the number of stops for pickup and discharge of passengers, the following advantages can be attained:
   a- Reduction in total travel time.
   b- Increasing the comfort of passengers.
   c- Increasing safety.
   d- Reducing the operation cost of the bus.
   e- Improving traffic flow and traffic operations.
10- By using new models of buses, the following advantages can be attained:
   a- Reducing air pollution.
   b- Reduction in total travel time.
   c- Increasing the comfort of passengers.
   d- Increasing safety.
   e- Reducing the operation cost of the bus.
11- By using the public transit system instead of using private cars, the following advantages can be attained:
   a- Reducing the congestion on the road network especially during peak hours
   b- Reducing the cost of traveling for the public.
   c- Increasing the efficiency of the roads.
   d- Increasing safety.
   e- Reducing the maintenance cost of the roads.
   f- Improving traffic flow and traffic operations.
   g- Reducing air pollution and preserving the environment.
12- The improvement of the public transit system is very essential in order to attract more people to use it. The improvement could be through one of the following:
   a- Increasing the number of buses to a reasonable number.

b- Using newer models of buses.
c- Limiting and placing the bus stops in good and safe locations.
d- Continuous inspection on the buses, and bus drivers.
e- Using smaller, faster buses.
f- Improving bus drivers' situation.

9. Recommendations

1- There must be continuous improvement on the public transit system in order to be able to compete with other modes of transportation, and to convince the public to use it. The improvements include the following:
    a- Increasing the number of buses to a reasonable number.
    b- Using newer models of buses.
    c- Limiting and placing the bus stops in good and safe locations.
    d- Continuous inspection on the buses and bus drivers.
    e- Using smaller, faster buses.
    f- Improving bus drivers' situation, in order to drive in a better mood and to do their job better.
2- There must be continuous inspection and surveillance on bus drivers in order to make sure they follow the traffic rules and regulations. Also, there must be continuous inspection on buses in order to be within specifications and safety regulations.
3- The authorities must determine fixed locations for bus stops for each line, and they must force the bus drivers to stop for pickups and discharge of passengers only at the bus stops.
4- It is recommended to have bus priority treatment, such as: Exclusive bus lanes or any other priority in order to increase capacity and efficiency and to reduce travel time and delay.
5- Spreading of the peak period demand through the implementation of staggering work schedule.

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Table 1: Data Collected by Using Public Transit System for Amman-Sweileh Line

TRIP NUMBER	Y1	Y2	X1	X2	X3	X4	X5	X6	X7	X8	X9
1	15	13.08	4	1	1	1.92	1.00	0.92	1	1	5
2	19	16.58	15	0	1	2.42	2.08	0.33	1	1	4
3	19	15.52	14	1	1	3.48	2.37	1.12	1	1	6
4	20	17.20	13	0	1	2.80	2.37	0.43	1	1	7
5	24	19.08	14	0	0	4.92	2.38	2.53	1	1	10
6	19	16.20	11	0	1	2.80	2.13	0.67	1	1	5
7	15	13.47	7	1	1	1.53	1.15	0.38	1	1	7
8	23	18.92	17	0	0	4.45	3.32	1.13	1	1	5
9	17	14.17	10	1	1	2.83	1.97	0.87	1	1	5
10	19	15.82	11	1	1	3.18	1.72	1.47	1	1	4
11	22	19.22	8	1	1	2.78	2.48	0.30	1	1	7
12	21	17.83	16	0	1	3.17	2.98	0.18	1	1	5
13	21	17.42	16	0	1	3.58	1.87	1.72	1	1	6
14	22	19.23	11	1	0	2.77	2.42	0.35	1	1	7
15	21	18.18	14	0	1	2.82	2.32	0.50	1	1	6
16	25	19.30	15	0	1	5.70	2.55	3.15	1	1	22
17	23	19.37	9	1	0	3.63	1.93	1.70	0	0	11
18	18	14.87	13	1	1	3.13	2.50	0.63	0	0	8
19	22	17.22	20	0	1	4.78	4.40	0.38	0	0	8
20	18	14.67	13	1	1	3.33	3.12	0.22	0	0	9
21	22	16.27	24	1	1	5.73	4.02	1.72	0	0	9
22	19	14.63	13	1	1	4.37	4.12	0.25	0	0	10
23	21	15.80	16	1	1	5.20	4.45	0.75	0	0	8
24	18	16.67	12	1	1	3.33	2.67	0.67	0	0	6
25	18	13.95	13	1	1	4.05	2.22	1.83	0	0	8
26	19	14.83	16	1	1	4.17	3.28	0.88	0	0	5
27	26	15.50	35	0	1	10.50	8.77	1.73	0	0	9
28	20	13.38	17	1	1	3.62	3.30	0.32	0	0	11
29	23	18.05	16	0	1	4.95	2.87	2.08	0	0	12
30	22	17.28	13	1	0	4.72	3.55	1.17	0	0	11
31	19	15.02	18	1	1	3.98	2.85	1.13	0	0	9
32	18	15.13	14	1	1	2.87	2.50	0.37	0	0	7

Table 2: Descriptive Statistics for Trips by Using Public Transit System

Descriptive Statistics

	N	Minimum	Maximum	Sum	Mean	Std. Deviation
Y1	32	15.00	26.00	648.00	20.2500	2.61509
Y2	32	13.08	19.37	523.86	16.3706	1.92065
X1	32	4	35	458	14.31	5.367
X2	32	0	1	20	.63	.492
X3	32	0	1	27	.84	.369
X4	32	1.53	10.50	123.51	3.8597	1.59411
X5	32	1.00	8.77	91.66	2.8644	1.36196
X6	32	.18	3.15	31.88	.9963	.74137
X7	32	0	1	16	.50	.508
X8	32	0	1	16	.50	.508
X9	32	4.00	22.00	252.00	7.8750	3.39592
Valid N (list wise)	32					

Table 3: Data Collected by Using Private Car

Trip No.	Travel Time	Running Time	Delay Time	Direction
1	13.25	11.77	1.48	0
2	12.50	12.35	0.15	0
3	12.33	11.40	0.93	0
4	13.08	11.91	1.17	0
5	12.66	12.08	0.58	0
6	13.10	12.32	0.78	1
7	14.08	12.58	1.50	1
8	13.05	12.83	0.22	1
9	14.25	12.20	2.05	1
10	14.50	12.17	2.33	1

Table 4: Descriptive Statistics for Trips by Using Private Car

Variable	N	Mean	Std Dev	Sum	Min	Max
Travel time	10	13.28	0.75	132.80	12.33	14.50
Running time	10	12.16	0.41	121.61	11.40	12.83
Delay time	10	1.12	0.73	11.19	0.15	2.33

Table 5: Correlation Matrix for All Variables

Correlations

		Y1	Y2	X1	X2	X3	X4	X5	X6	X7	X8	X9
Y1	Pearson Correlation	1	.752**	.583**	-.527-**	-.426-*	.713**	.548**	.526**	-.049	-.049	.509**
	Sig. (2-tailed)		.000	.000	.002	.015	.000	.001	.002	.792	.792	.003
	N	32	32	32	32	32	32	32	32	32	32	32
Y2	Pearson Correlation	.752**	1	.047	-.513-**	-.548-**	.140	-.009	.315	.307	.307	.259
	Sig. (2-tailed)	.000		.800	.003	.001	.446	.963	.080	.087	.087	.153
	N	32	32	32	32	32	32	32	32	32	32	32
X1	Pearson Correlation	.583**	.047	1	-.370-*	.123	.856**	.867**	.247	-.390-*	-.390-*	.179
	Sig. (2-tailed)	.000	.800		.037	.502	.000	.000	.173	.027	.027	.326
	N	32	32	32	32	32	32	32	32	32	32	32
X2	Pearson Correlation	-.527-**	-.513-**	-.370-*	1	.022	-.270	-.177	-.254	-.387-*	-.387-*	-.087
	Sig. (2-tailed)	.002	.003	.037		.904	.134	.334	.160	.029	.029	.636
	N	32	32	32	32	32	32	32	32	32	32	32
X3	Pearson Correlation	-.426-*	-.548-**	.123	.022	1	-.065	.046	-.224	-.086	-.086	-.119
	Sig. (2-tailed)	.015	.001	.502	.904		.722	.801	.218	.640	.640	.516
	N	32	32	32	32	32	32	32	32	32	32	32
X4	Pearson Correlation	.713**	.140	.856**	-.270	-.065	1	.886**	.522**	-.422-*	-.422-*	.438*
	Sig. (2-tailed)	.000	.446	.000	.134	.722		.000	.002	.016	.016	.012
	N	32	32	32	32	32	32	32	32	32	32	32
X5	Pearson Correlation	.548**	-.009	.867**	-.177	.046	.886**	1	.067	-.500-**	-.500-**	.196
	Sig. (2-tailed)	.001	.963	.000	.334	.801	.000		.714	.004	.004	.282
	N	32	32	32	32	32	32	32	32	32	32	32
X6	Pearson Correlation	.526**	.315	.247	-.254	-.224	.522**	.067	1	.009	.009	.581**
	Sig. (2-tailed)	.002	.080	.173	.160	.218	.002	.714		.959	.959	.000
	N	32	32	32	32	32	32	32	32	32	32	32
X7	Pearson Correlation	-.049	.307	-.390-*	-.387-*	-.086	-.422-*	-.500-**	.009	1	1.000**	-.280
	Sig. (2-tailed)	.792	.087	.027	.029	.640	.016	.004	.959		.000	.120
	N	32	32	32	32	32	32	32	32	32	32	32
X8	Pearson Correlation	-.049	.307	-.390-*	-.387-*	-.086	-.422-*	-.500-**	.009	1.000**	1	-.280
	Sig. (2-tailed)	.792	.087	.027	.029	.640	.016	.004	.959	.000		.120
	N	32	32	32	32	32	32	32	32	32	32	32
X9	Pearson Correlation	.509**	.259	.179	-.087	-.119	.438*	.196	.581**	-.280	-.280	1
	Sig. (2-tailed)	.003	.153	.326	.636	.516	.012	.282	.000	.120	.120	
	N	32	32	32	32	32	32	32	32	32	32	32