

Modal split Analysis

Traffic Engineering &
Transportation Planning

Modal split is the process of separating person trips by the mode of travel. It is usually expressed as a fraction, ratio or percentage of the total number of trips made by private car to public transport (road & rail).

Factors Affecting modal split :-

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1. Characteristics of the trip
2. Household characteristics
3. Zonal Characteristics
4. Network characteristics

1. Characteristics of the trip :-

(i) Trip purpose : - The choice of mode of selection depend on the trip purpose. for ex:- home based school trips have a high rate of usage of public transport.

On the other hand home based shopping journeys can have a higher rate of private car usage, for the simple reason that it is more convenient to shop when travelling in a personalised transport.

(ii) Trip length : - The length can govern an individual's choice of a particular mode. A measure of the trip length is also possible by the travel time and cost of travelling.

2. Household characteristics :-

(i) Income : - The income of a person is more he is prepared to incur on a journey. Higher income groups are able to purchase and maintain private cars, and thus private car trips are more frequent as the income increases.

ii) Car ownership : Car ownership is inter depend on the income for this reason both income and car ownership are inter-related to each other. In general, families which own a car prefer private car trips, families without car prefer public transport.

iii) Family size and composition :

The number of persons in the family, the number of school-going children, the number of income earners, the number of unemployed, the age-gender structure of the family.

Zonal characteristics :

i) Residential density : The use of public transport increases as the residential density increases. This is because of the fact that areas with highest residential density are with lower income, with lower levels of private car ownership. It is also found that higher density areas are preferred Public transport system.

Network characteristics

ii) Accessibility ratio : Accessibility ratio is a measure of the relative accessibility of that zone to all other zones by means of mass transit network.

ii) Travel time ratio : The ratio of the travel time by public transport and travel time by private car gives a measure of the attractiveness of public transport system.

The travel time by public transport system is itself composed of :-

- a) time spent walking to public transport vehicle at origin.
- b) time spent for waiting for public transport vehicle.
- c) time spent in public transport vehicle.
- d) time spent in transfer from one public transport vehicle to another.
- e) time spent walking from public transport vehicle at destination.

Travel time by Private car is composed of

- a) time spent driving the car,
- b) time spent in parking at destination.
- c) time spent in walking from parked to destination.

(ii) Travel cost ratio :

The ratio of cost of travel by public transport and cost of travel by car is one of the most important factors influencing modal choice.

Modal Split in the Transport Planning Process

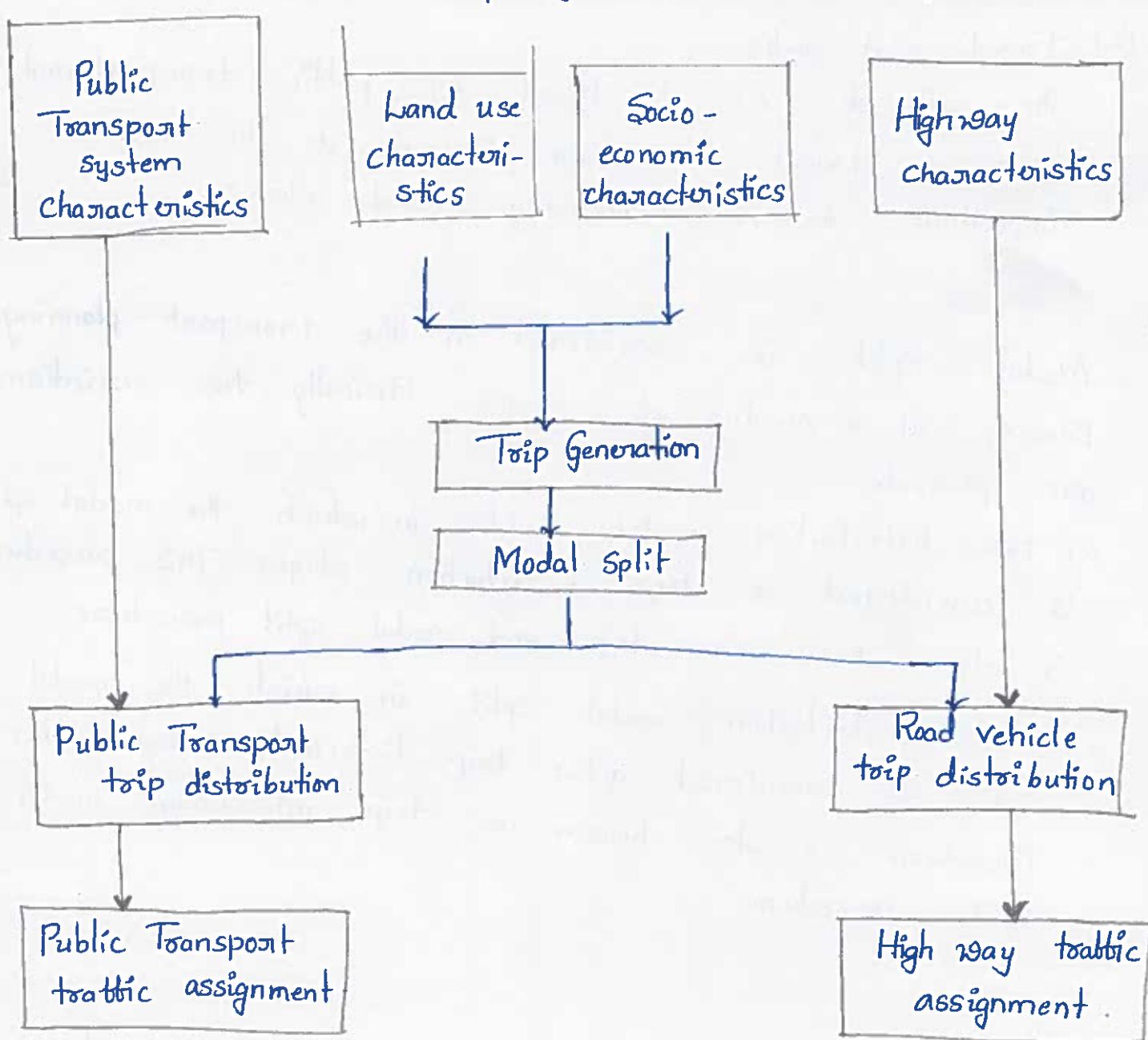
Modal split is considered in the transport planning process at a number of stages. Basically, two variations are possible :

- (i) Pre-distribution modal split, in which the modal split is considered to trip distribution stages. This procedure is also known as trip end modal split procedure.
- (ii) Post-distribution modal split, in which the modal split is considered after trip distribution stage. This procedure is also known as trip interchange modal split procedure.

ii) Pre-distribution modal split - trip end type modal split:

If modal split is carried out after generation but before distribution, the trip generations are calculated assuming that the mode of travel has no influence on trip generation. After thus determining the total trip productions and attractions, these trips are allocated to the public transport system and private car by considering the relative attractiveness of each mode as measured by variables considered to govern modal split. Distribution is then carried out. A flow diagram for this procedure is given in Table 3.1.

Flow Diagram for Modal Split Carried out between Trip Generation and Trip Distribution.



The advantages of the pre-distribution modal split

Procedures are:

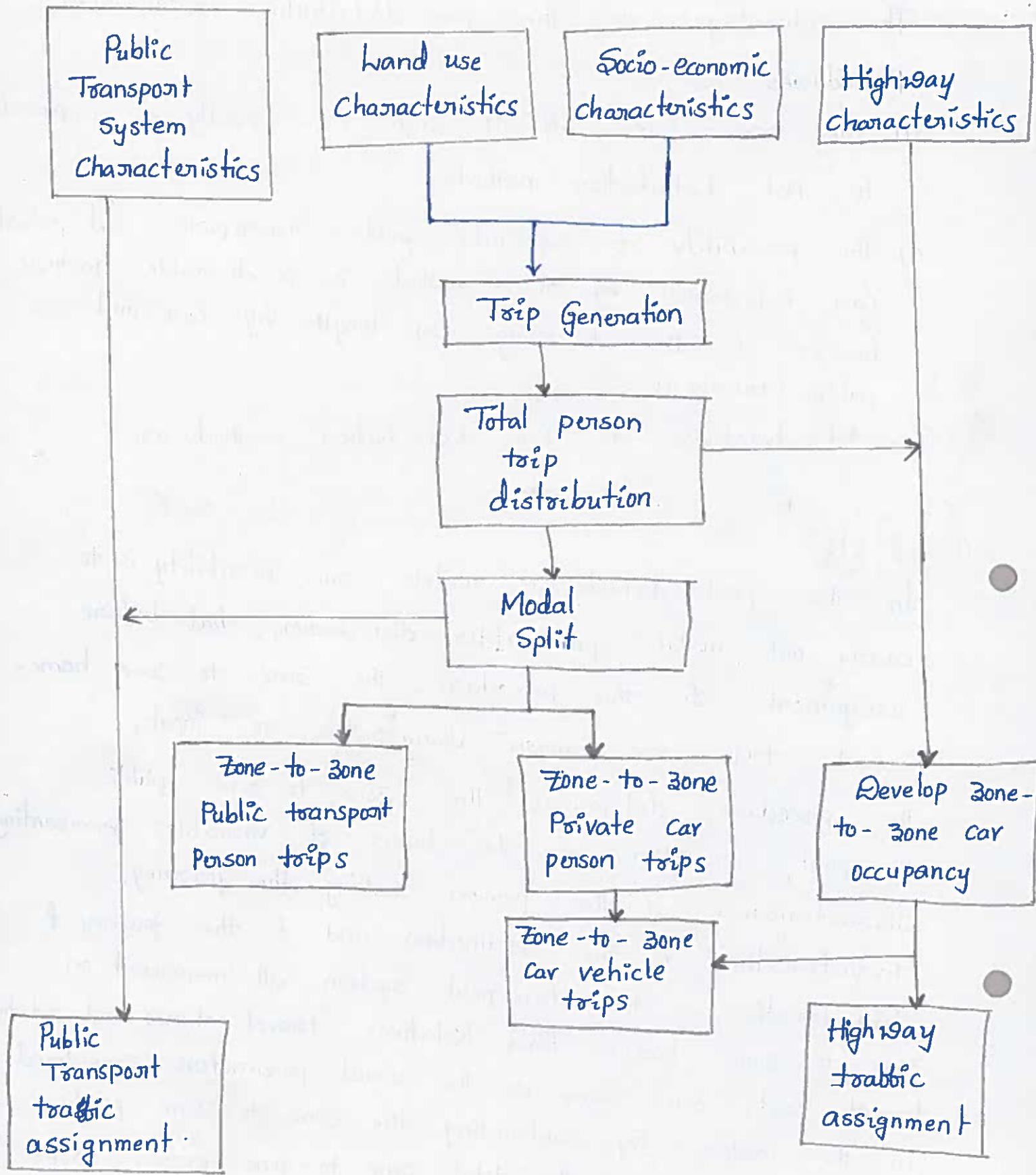
- (i) They are less difficult and less costly as compared to Post distribution methods.
- (ii) The possibility of separate public transport and private car distribution by this method is a desirable feature because of the differing trip lengths by car and public transport.

The disadvantages of Pre-distribution methods are:

(i) Post-distribution (or) trip interchange modal split

In the post-distribution models, one possibility is to carry out modal split after distribution, but before assignment. In this procedure, the zone-to-zone home-based trips are known. Using this as input, the procedure determines the zone-to-zone public transport travellers on the basis of variables representing characteristics of the person making the journey, characteristics of the destination end of the journey & characteristics of the transport system all measured on zone-to-zone basis. Relative travel times and relative travel costs are some of the usual parameters considered in the models. By subtracting the zone-to-zone public transport trips from the total zone-to-zone person-trips, the person trip made by motor vehicle are derived.

A flow diagram for a model of the above type is given Table 2.



Advantages of trip interchange type:

- i) It is useful in situations where serious consideration is given to public transport planning.
- ii) The method makes it possible to develop modal split relations based on a wide range of transport system variables influencing modal choice.

iii) The method considers private car and public transport usage on a zone-to-zone basis instead of a zonal basis as in the predistribution methods.

Disadvantages

- (i) The trip interchange model is more complex, especially if the number of zones is large.
- (ii) It also suffers from another drawback in that the total person trip distribution is carried out before any modal choice is considered.
- (iii) This ignores the differing lengths of journey by car and public transport.

Trip-End Type Modal Split Model :

The socio-economic characteristics of trip makers were defined on zonal basis, in terms of the average number of cars per household, in a zone.

The characteristics of the transport system relative to a given zone were defined by an accessibility index calculated from the following equation

$$ACC_i = \sum_{j=1}^n a_j f_{ij}$$

Where

ACC_i = accessibility index for zone i.

a_j = number of trip attraction in zone j.

f_{ij} = travel time factor for travel from zone i to zone j for particular mode being considered.

n = no. of zones in the urban area.

Ex:- Calculate Accessibility Index for Zone 1

$$\text{acc}_i = \sum_{j=1}^n A_j f_{ij} = \sum_{j=1}^n A_j (t_{ij})^{-2}$$
$$= A_2(t_{12})^{-2} + A_3(t_{13})^{-2} + A_4(t_{14})^{-2} + A_5(t_{15})^{-2} + A_6(t_{16})^{-2}$$

Car Accessibility Index

$$= 200 \times 0.0011 + 100 \times 0.0069 + 150 \times 0.0025 + 250 \times 0.0044 + \\ 300 \times 0.0016 = 2.8828$$

Public Transit Accessibility Index

$$= 200 \times 0.0006 + 100 \times 0.0025 + 150 \times 0.0016 + 250 \times 0.0025 + 300 \times 0.0011 \\ = 1.5733$$

$$\text{Accessibility Ratio} = 2.8828 / 1.5733 = 1.8322$$

$$\text{Accessibility Ratio} = \frac{\text{Private mode accessibility index}}{\text{Public transport accessibility index}}$$

Trip interchange type Modal split Model :-

Trip interchange type depend on Relative travel time, Relative travel cost, relative travel service, and the economic status of the trip maker

⇒ Relative travel time expressed as Travel time Ratio (TTR) is given as,

$$\text{TTR} = \frac{a+b+c+d+e}{f+g+h}$$

where

a = time spent in the public transport vehicle

b = transfer time b/w Public transport vehicle

c = time spent waiting for public transport vehicle

d = Walking time to public transport vehicle

e = Walking time from Public transport vehicle

f = Car driving time

g = Parking delay at destination

h = Walking time from Parking place to destination

⇒ The Relative travel cost was defined by the ratio of travel cost by public transport and Private transport as follows :

$$CR = \frac{i}{(j+k+0.5l)/m}$$

where

i = Public transport fare (charges)

j = Cost of petrol

k = Cost of Oil, lubricants, etc.

l = Parking cost at destination, if any

m = average Car Occupancy

⇒ The Relative travel Service was characterised by the ratio of the excess travel time by public transport and car.

The excess travel time was defined as the time spent out side the vehicle during a trip.

Thus the Service Ratio defined as follows :-

$$SR = \frac{b+c+d+e}{g+h}$$

Logit Model of Mode Choice :-

A mode choice situation involving two modes (1 & 2)

where 40% of travellers make use of mode 1

can be mathematically represented as follows.

$$P(1) = \frac{40}{100}$$
$$= \frac{40}{40+60}$$

$$P(1) = \frac{U_1}{U_1 + U_2}$$

If m nodes are involved

$$P(j) = \frac{U_j}{\sum_{k=1}^m U_k} \quad \dots \textcircled{1}$$

$$P(j) = \frac{e^{V_j}}{\sum_{k=1}^m e^{V_k}} \quad \dots \textcircled{2}$$

where,

$P(j)$ is the probability of choice of alternative j .

' m ' is the number of alternative modes including ' j '.

$$P(j) = \frac{e^{V_j}}{\sum_{k=1}^m e^{V_k}} \quad \text{or equation is known as}$$

logit model of mode choice.

example 1 :- Application of the Logit Model.

~~Y-axis~~ A calibration study resulted in the following utility function

$$V_k = a_k - 0.025x_1 - 0.032x_2 - 0.015x_3 - 0.002x_4$$

Unit-4, Pg - 10/12

x_1 = access + egress time in min. [time to the transit, time from the transit to the destination.]

x_2 = waiting time in min

x_3 = line-haul time in min [In Vehicle time]

x_4 = Out of pocket cost in Rupees, [Cost of charges] (fare charges)

Problem 1 :-

The zonal trip interchange in the target-year is 5,000 person trips per day. During the target year, trip makers will have a choice between motorised two-wheeler (M) and city bus (B).

The target-year service attributes of the two competing modes have been estimated to be as follows.

attribute	x_1	x_2	x_3	x_4
Motorised Two-wheeler	5	0	20	10
City Bus	10	15	40	5

Assuming that the calibrated mode-specific constants are 0.00 for the motorised two-wheeler and -0.10 for the bus mode, apply the logit model to estimate the target-year market share of the two modes and the resulting fare-box revenue of the bus system.

Soln The utility equation

$$a_k \text{ for motorised two-wheeler} = 0$$

$$a_k \text{ for bus mode} = -0.10$$

$$(\text{Motorised two-wheeler}) V_M = a_k - 0.025x_1 - 0.032x_2 - 0.015x_3 - 0.002x_4$$

$$V_M = 0 - 0.025(5) - 0.032(0) - 0.015(20) - 0.002(10)$$

$$= -0.445$$

$$V_B = -0.10 - 0.025(10) - 0.032(15) - 0.015(40) \\ - 0.002(5)$$

$$V_B = -1.440$$

According to the logit equation

$$P(M) \approx e^{-0.445} \\ P(j) = \frac{e^{V_j}}{\sum_{k=1}^m e^{V_k}}$$

$$P(M) = \frac{e^{-0.445}}{e^{-0.445} + e^{-1.440}} = 0.73$$

$$P(B) = \frac{e^{-1.440}}{e^{-1.440} + e^{-0.445}} = 0.27$$

Market share to each mode

$$\Omega(M) = (0.73)(5,000) = 3650 \text{ trips/day}$$

$$\Omega(B) = (0.27)(5,000) = 1350 \text{ trips/day}$$

Fare-based revenue estimated is

$$(1350)(5) = 6,750 \text{ per day}$$