CHAPTER 7

URBAN TRANSPORTATION

7.1 INTRODUCTION

The purpose of this chapter is to describe and explain the difficulty of urban transportation due to the highly concentrated number of people as well as goods and services that are on the move daily. Transportation in an urban area is used to move both people and freight. The desire to pursue an activity at some other location demands transportation. Activities include work, school, shopping and entertainment to mention but a few. Streets, highways and railways are all examples of facilities to transport people and goods to and from their desired destination.

This chapter will focus mainly on one type of travelling *viz.* commuting, i.e. the transportation of people for the exchange of labour services. The reason is that the journey to work is probably the most important of an adult's daily life, and that these trips are concentrated during the morning and afternoon rush hours. This leads to a high level of strain on the capacity of the transportation system and facilities to move people on a daily basis. Trips to school (cars) and other trips (trucks) during peak hours are also included. The size, structure and efficiency of an urban area is influenced by the transportation system in which people and goods are moved.

7.2 MODAL CHOICE

Consumers choose among available modes according to the terms on which the modes are made available and according to their needs and tastes. The public sector's task is to provide the urban transportation system that best serves the community. An important constraint on the public sector is that the public buys transportation services and can register dissatisfaction with one mode by purchasing the services of another.

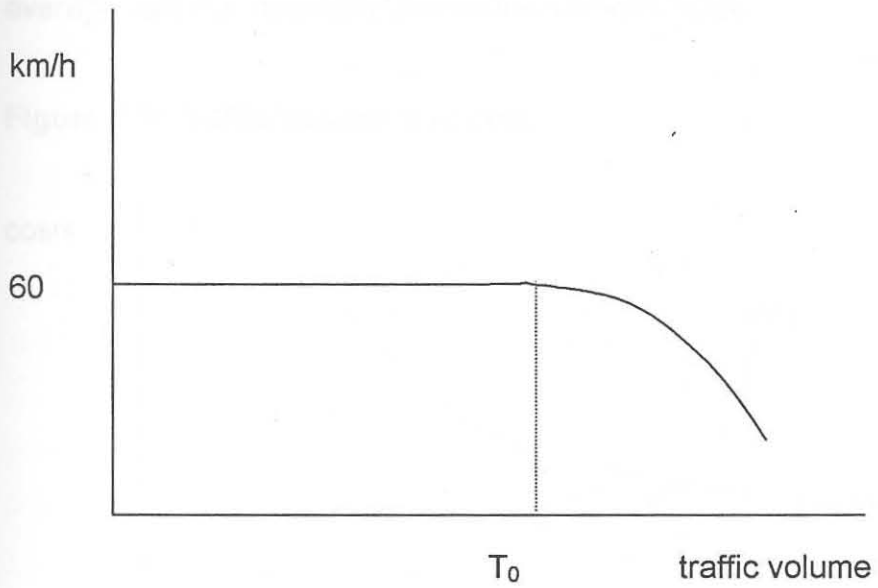
The activity of commuting to work can be divided into three phases. The first is the suburban collection, which involves getting from the house to the main mode of commuting. The second phase is the line haul that involves travelling using the main mode of commuting. The third phase is the workplace distribution that involves getting from the line-haul vehicle to the office (Mills & Hamilton, 1994: 285). The suburban collection portion of the commute can be the walk from the door to the car and perhaps a short drive to the main street. If the trip is by bus, residential collection refers to the walk to the bus stop. If the trip is by rail, residential collection may consist of a walk or a car or bus ride to the station where the worker boards the train. The line haul is the drive to the office or working place and the workplace distribution refers to the part of the trip after the line-haul vehicle has been left. Most commonly, this part is made on foot but may entail a bus or taxi ride for some workers. People using train rides as their main form of line haul contribute to congestion only on their way to the train station (suburban collection) and once they depart from the train to their specific place of work (workplace distribution). Both of these phases are of shorter duration and have less impact on the general transportation system.

The choice of line-haul vehicle is known as the modal choice although the choice of collection and distribution modes is clearly related and important. The transport mode chosen by a worker depends on the characteristics of all three parts of the trip. Trip characteristics that appear to have the greatest influence on modal choice are the time and money costs of each part of the trip. Certain other modal characteristics such as comfort and privacy may also affect modal choice. In addition, characteristics such as age and income of the worker may also influence such modal choice (Mills & Hamilton, 1994: 285). An important factor is the monetary value that people place on their time. The key issue is the cost of time - especially time spent waiting - which plays an important role in the choice of the mode of commuting.

7.3 CONGESTION

Transportation facilities are built in response to current or projected demands. Sometimes transportation facilities have been built ahead of demand but often the construction of facilities responds to demand forces that already exist. Urban transportation facilities are important in shaping an urban area and strongly influence land-use patterns and spatial patterns of urban travel. Urban transportation systems and urban land-use and travel demands are interdependent and evolve together over time (McDonald, 1997: 169). It is also important to realise that large-scale transport facilities often become political issues and that many role players are involved. The planned construction of transportation facilities is sometimes influenced by a particular constituency with a vested interest or by budget and policy decisions from national government.

Figure 7.1: Traffic volume and speed

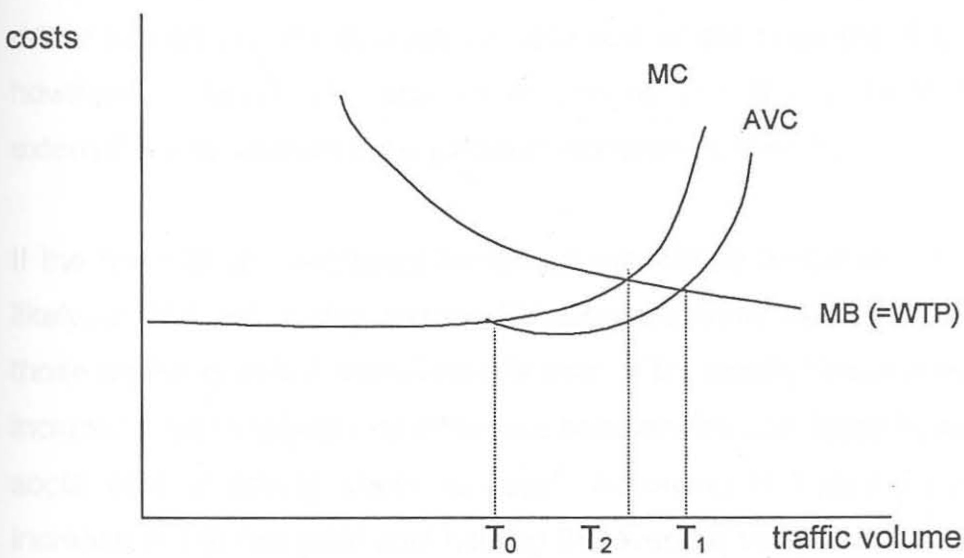


Source: Bogart. 1998.

Congestion starts when the volume of traffic increases and the average speed of vehicles slows down. If the speed limit is 60 kilometres per hour (km/h) and everyone adheres to the speed limit, the traffic below some critical volume will be able to maintain its average speed at 60km/h. At any volume above the critical level, the average speed will be slowed down as cars start to interfere with each other. The relationship between speed and volume can be seen in Figure 7.1. The volume T_0 is known as the "design capacity" of the road. The average speed at which traffic travels obviously has implications for the total cost of travel.

The time costs are, for example, negatively related to speed because the faster the speed of a car, the sooner the time of arrival. Small (1992: 76) determined that costs are higher when congestion forces the average speed below the speed limit (60km/h). Suppose, for the moment, that the inconvenience caused by the traffic does not depend on volume (although this would be totally unrealistic). Suppose, also, that operating costs depend only on distance traveled and not speed. By allocating a value to travel time, Figure 7.1 can now be transformed into a relation between traffic volume and average variable cost with time as the variable input.

Figure 7.2: Traffic volume and cost



Source: Bogart. 1998.

This is shown in Figure 7.2 where the average variable costs are the sum of the time costs (which vary with volume) and the operating costs (which are assumed not to vary with volume). The marginal cost (MC) of adding another car to the road is simply the addition to total variable cost. The marginal cost and average variable cost (AVC) are constant up to the design capacity of the road (T_0) because the speed of traffic is constant at all these volumes.

Up to this point, the travel time per car does not vary for these volumes. The demand for travel reflects the marginal benefit (MB) to the traveller expressed as the traveller's willingness to pay (WTP). The marginal benefit curve is downward sloping because people's preference may differ or one person may have fewer alternative travel routes. In equilibrium, the marginal benefit to the last traveller will equal the price of travelling.

A negative externality is shown in Figure 7.2. Each person travelling pays the average variable cost but imposes an additional portion on total cost and thus marginal cost. A difference between private cost and total social cost arises because not all drivers take into account their own contribution to delaying other drivers by reducing the average speed. The travel volume will be T_1 in equilibrium, where the marginal benefit of the last driver just equals the average variable cost or the price the driver should pay. This, however, exceeds the optimum volume of T_2. If the driver took the congestion externality into account the equilibrium volume would be T_2.

If the level of inconvenience increases with higher levels of volume, as seems more likely, another externality arises. Pollution is another externality which upsets not only those on the road but also everyone else. If the level of inconvenience and pollution is included in the analysis, the difference between the cost faced by the driver and the true social cost of driving would increase. According to Figure 7.2 this would mean an increase in the marginal cost holding the average variable cost constant, which would reduce the optimal traffic volume to an even lower level than T_2.

Another private cost should also be considered. Once the road is congested, drivers depart earlier than they would otherwise have, arrive later at their destinations or alter their travel plans altogether. Drivers also impose several social costs. The first is the cost of time they impose on other drivers. Secondly, there is the external cost of motor accidents. This cost has several elements such as the extra traffic delay due to the accident, lost production resulting from death or injury, property damage and insurance administration. The third social cost is the provision of parking at the end destination. The type of parking and the type of location in terms of land value will determine the extra cost incurred (Bogart, 1997: 324). Other related costs are the public services such as traffic control and costs of courts. Furthermore, noise and air pollution, as well as environmental degradation result from road construction.

7.3.1 Reducing congestion

Traffic congestion leads to negative externalities which should be addressed in some effective manner. The generic term for remedying road congestion is a congestion toll. To implement such a toll is, however, not without a cost. The toll should only be implemented if the benefit of the toll exceeds the costs. The most promising solution would be to force drivers to face the full social costs by imposing a toll equal to the congestion costs being imposed on others. A direct regulation would involve mandating which cars are allowed to use the road at various times of the day. Synchronising traffic lights could reduce waiting time and increase the flow of traffic. A variety of technological improvements may also be proposed as a solution to congestion. Annon (1995) lists satellite navigation, roadside traffic computers, collision avoidance radars, infrared blind-spot sensors, infrared night-vision screens, radar-enhanced cruise controls, programmable traffic signs, etc. as possible solutions which are currently available or will be in due course. Although all of these technologies may reduce congestion, they do so at a cost.

The purpose of a toll is to ensure that roads are used efficiently and is not necessarily intended to raise revenue or reduce the number of trips made by drivers. It is supposed to make a person contemplate a trip by taking into account all the related costs associated with that specific trip. If the government uses the toll revenues to lower other taxes paid by users of the road, everybody benefits from the toll. If the government uses the toll revenue to lower taxes generally or to provide services that residents want more than tax reduction, the benefits exceed the cost of the toll policy.

Only if the government uses the toll revenues wastefully will the toll programme costs exceed the benefits (Mills & Hamilton, 1994: 290). If congestion still takes place after imposing an optimal congestion toll, it can be assumed that the benefits of driving clearly exceed the costs. It is important for a congestion toll to vary with the time of day (since congestion varies with the time of day) and location (since congestion varies from place to place). One of the important roles of an efficient congestion toll is to discourage people from taking non-working trips (shopping) during rush hour. Only if the toll declines during off-peak hours do they properly encourage substitution between peak and off-peak travel times.

A congestion toll could be collected in several ways. The direct way of collecting toll through toll booths may cause additional congestion as traffic slows down to pay the toll amount. The indirect methods of making people face the full cost of commuting also hold some disadvantages. These methods include fuel tax, parking tax and subsidies for public transportation. The main problem with all of these is that they are not necessarily related to the operation of motorvehicles in congested situations.

According to Downs (1992: 69) the level of fuel taxes needed to make a significant reduction in driving is estimated to be very high. Although it may not be true everywhere, he estimated that a doubling of fuel prices would lead to a short-term decrease of only 35 per cent in fuel consumption, the reason being that a fuel tax would provide an incentive to reduce the use of the car at all times and not only in peak hours. A fuel tax may further encourage a shift to cars with better fuel consumption rather than a shift in driving habits and driving times. This view was emphasised by Meyer and Gomez-Ibanez (1981: 145) that the demand for fuel is inelastic. Parking taxes also only affect those who actually stop at that particular location. Although easy to collect, parking taxes do not distinguish between drivers who travel on congested routes and those who travel on uncongested routes.

Various methods of taxing motorists normally fail to cope with current traffic congestion. No distinction is made between locations where congestion costs are high or low; no discrimination is made between times when congestion costs rise or fall; more fuel tax is paid by heavy-fuel-consuming vehicles than low-fuel-consuming vehicles; factors are completely independent of location, time of the day, or day of the week and the degree of congestion. Alternative indirect methods of charging motorists may be proposed, e.g. a tyre tax as an alternative to fuel tax, and differential licence taxes. These licences can relate to different zones in an urban area for example, an expensive red inner zone and a less expensive blue outer zone that can be purchased for periods from a year to a day. Licence discs would be displayed on the vehicle with an exemption at night and at weekends (Balchin, *et al.*, 1995: 220).

Subsidies for public transportation are a second-best solution to the problem of congestion. This is based on the principle of reducing the cost of alternatives in order to encourage people to switch modes of transportation. However, the subsidy required to have a relatively large impact is fairly high. The convenience of private cars as well as the fact that they are very comfortable may swing the scale away from public transportation. Public transportation makes sense if a person is unable to afford a motorcar and also if the person is travelling to places served by the public transport system. In a monocentric city, almost all business and industrial related destinations will be in the CBD. In decentralised cities, it is uncertain whether all destinations will be efficiently accessible using public transport. Meyer and Gomez-Ibanez (1981) present evidence that one option that combines the efficiency advantages of public transportation with the comfort of the private car is ride sharing or car pooling.

7.3.2 Expanding roads

One possible way to alleviate traffic congestion is by expanding existing roads or building more roads and thus increasing the available consumer surplus to drivers. The supply side is clearly a public-sector responsibility. Streets and highways are normally constructed, maintained and owned by government. However, the expansion or construction of new roads comes at a cost. If these costs exceed the increase in consumer surplus, it is not socially desirable to expand the roads. It should be noted that different types of roads have different costs and operating volumes. Small (1992: 100) describes the relationship between type of road and cost per kilometre. He argues that there are decreasing returns to scale where various arterial roads are the lowest-cost alternatives, and increasing returns to scale when the volume becomes sufficient to justify expressways.

Three cost aspects should also be taken into account. Firstly, the construction cost of the road will vary depending on the design of the road and the nature of the terrain. Secondly, the acquisition of land on which to build the road will vary according to the location of the road. Lastly, the operating costs, including painting, traffic enforcement and maintenance, should also be considered.

7.4 PARKING

Every person driving in a private vehicle to go about his/her business, must do something with the vehicle upon arrival at his or her destination. Garreau (1991) argues that much of the land use in cities can be understood by the imperative to accommodate all these motor cars. He estimates that less space is required for a typical office worker than for a typical parking space and therefore the major use in an edge city is for parking lots.

A quote from the Assyrian king Sennacherib (Garreau, 1991: 119) suggests that parking has been an important issue since the seventh century B.C.

> *Anyone parking a chariot so as to obstruct the royal road should be put to death with his head impaled on a pole in front of his house.*

Developers have different options in providing parking places for motor cars. One option is to designate a vacant piece of land next to the office block or mall as a parking lot. Although it may be a wasteful use of land, it could be inexpensive, depending on the value of the vacant lot. Another option may be the construction of a multi-storey parking lot above ground, thereby using the land more extensively and improving the efficiency of land use. This, however is a more expensive form of parking provision. Lastly, excavations may be considered to construct an underground parking lot. This method is an even more efficient use of land because land may now be used for both parking and commercial or residential purposes. This is unfortunately also the most expensive alternative in parking provision.

The consideration to built parking garages is thus an option when the land is too valuable to be left idle or is in low-intensity use. Once the density of economic activity reaches a certain level it will become worth building parking garages. Large fixed costs are involved in constructing parking garages, which implies some measure of increasing returns to scale in the number of storeys in a parking garage, because the fixed costs can be spread over a number of storeys. When it becomes worthwhile to build a parking garage, it will be cost-effective to build a large one relative to the surface parking it is to replace.

One condition that should be kept in mind under these circumstances is that it is necessary for an area to generate enough traffic to justify that many parking spaces. Parking fees can be collected as the land values become more expensive. One quick and easy way to determine the value of land in an area is to look at how tall buildings are, and how parking is managed (Jackson, 1985: 256). Technological advances continue to enhance unmanned parking machines, including parking meters that automatically clamp on tires when they expire and forklifts that can place up to eight cars in stacks and retrieve them in just one minute (Annon, 1996). The idea of using parking prices as a substitute for congestion tolls was discussed earlier. However, in many cases free parking, or parking at less than market rates, form part of an employee's job advantages and therefore provide an incentive to drive to work.

7.5 ENVIRONMENTAL DEGRAGATION

Although congestion is seen as a major negative externality due to the use of motor cars, one externality sometimes overlooked, is the relationship between the use of motor cars and global warming. Motor cars emit a variety of chemicals as a result of combustion of fuel. These chemicals include carbon monoxide (CO), carbon dioxide (CO_2), nitrogen oxides (NO_x) and nitrous oxide (NO_2) of which CO_2 is believed to be the most important in causing the so-called greenhouse effect that leads to a gradual warming of the earth's climate (Bogart, 1998: 331). Existing motor cars have attributes such as performance, fuel availability, expected reliability, and perceived safety. Although alternatively fueled vehicles may restrict the problem of pollution, they all fall short in comparison with petroleum driven fuel in some or all the dimensions. This uncertainty in terms of availability, performance and reliability of a new technology reduces the willingness of households to invest in alternatively fueled cars.

Every person driving in a motor car contributes to all the negative externalities already mentioned. It would therefore make sense to decrease the daily number of cars on the road but still transport everyone to his/her desired destination. This could be realised through the use of mass transit, resulting in less negative externalities and thus more effective and efficient transport.

7.6 MASS TRANSIT

It is important at this juncture to recall the division of commuting into three parts, *viz.* collection, line haul and distribution. Although the benefits of mass transit sometimes outweighs commuting in private motor cars in terms of line haul, increasing collection and distribution time and costs cancel out this advantage. Collection and distribution costs were precisely those to which commuters were most responsive, while being minimal for private motor cars. Collection and distribution costs is basically the transaction costs (opportunity cost) that increases when using mass transit instead of private motor cars.

7.6.1 Intermodal cost comparisons

If a bus system is taken as an alternative to private cars, the same type of road system can be used. By allocating reserved bus lanes and priority access to urban roads the efficiency of the transport system may be increased by a significant amount. This may be viewed as a strong second-best option to congestion tolls. Buses, like cars, emit pollution and require road construction and maintenance costs but they impose additional costs as well. A bus system requires both administrative and operating expenses like drivers, mechanical personnel, etc. The operating costs per passenger decrease with an increase in the number of passengers. Small (1992: 105) estimated that the total social costs of buses are lower than for motor cars, once the volume per bus has increased significantly. This will only be true during peak hours, so the advantage of using buses may be overstated.

A railway system is limited to a fixed path, making the residential collection and the downtown distribution even more problematic than in the case of buses. The railway system does, however, have the advantage of less congestion during the line haul. This type of transport mode will only be competitive once the number of passengers increases substantially. Five benefits related to railway are: Reduced travel time for the commuters that choose rail; reduced congestion on the roads; reduced motor car operating costs due to less congestion; reduced social costs because of a lower need for parking; and reduced bus operating costs. However, rail transit remains economically attractive only where the population densities are extremely high (Haring, 1972: 139). The rail system also relies on feeder buses, taxis and motor cars to bring passengers to suburban railway stations.

7.6.2 Subsidising transport

Two basic reasons can explain subsidies for mass transit. Firstly, mass transit is produced under conditions of increasing returns to scale. Thus, if the price of transit is set equal to marginal cost a deficit remains because marginal cost, is less than average cost. Two well-known resolutions can be used to overcome this problem. The first is to set price equal to average cost so that the operation may earn a normal rate of return but zero economic profits. The second resolution is the so-called two-part tariff, which is a tax imposed to cover the deficit remaining when marginal cost pricing is used. This form makes it possible for the transit operation to break even. This tax may be obtained from those benefiting most from the transit line and less congestion on roads such as motor car drivers. This may include a tax on fuel to subsidise the mass transit.

The second reason for subsidising mass transit is that unpriced congestion and pollution externalities mean that motor car travel is essentially subsidised. When subsidising mass transit it is important that the combination of fares and services render high value for money because many people may simply refrain from buying the service and use cars instead. Public transportation will only be attractive if it provides frequent, economical and safe service (Mills & Hamilton, 1994: 279).

It is difficult to present strong justifications for subsidising urban transit on economic grounds alone. In general, economic theory offers little direct help in defining policy objectives for urban transportation. Alternative pricing and subsidy policies can be evaluated for their technical feasibility, their probable effects on efficiency, their applicability to urban transportation markets and probable implications for income redistribution. However, it seems that in many cases current proposed urban transit subsidies, when subjected to careful economic evaluation, appear to be internally inconsistent, ill-conceived and often in conflict with other goals of government policy in urban areas (Haring, 1972: 141). For a transit system to operate without a subsidy, it should cover its capital costs from its rush-hour traffic.

7.7 SUMMARY

The purpose of an urban transportation system is to facilitate the exchange of goods and services and the movement of people. The optimum transportation system for an urban area depends on the size and structure of the area. A person's choice of transport mode depends on income, time and costs of alternative modes. Many people tend to choose motor cars because of their convenience relative to alternative modes.

The use of vehicles generates several negative externalities such as congestion and pollution. Congestion costs are an important element in planning and pricing urban transportation systems. One way to correct the externalities of congestion and pollution is to force drivers to face the full costs of their driving by charging a congestion toll. The optimal toll would vary by time of day and by travel route. Alternatives include fuel tax, parking tax or subsidies to public transit. One way of reducing congestion is the construction of additional roads. This implies major costs and the use of land that may have more efficient uses.

The efficiency of an urban area is influenced by the transportation system and should therefore enhance the urban environment and not constrain economic activity. Congestion, which restricts the flow of traffic, hampers the economic potential of urban areas and needs to be addressed by local authorities. An effective transportation system is one of the most important factors where local authorities may contribute to the improvement of the urban environment, to the benefit of businesses and residents.

The transportation system should ensure the effective transportation of labour services to the urban area on a daily basis. Labour services and the ingenuity of an area's people is vital to the growth potential of an urban area. For any urban area to experience sustainable economic growth, it is important to evaluate urban labour and migration changes in that area. The skills level of people and its migration patterns may have a severe impact on an urban environment. The influence and effect of these important labour-related features on an urban area will be analysed in the next chapter.