ECONOMIC EVALUATION OF PASSENGER TRANSPORT TERMINALS AND TRANSFER FACILITIES

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ABSTRACT

The economic benefit stemming from the construction and operation of passenger transport terminals and transfer facilities is equal to the savings it brings about in recurring costs. These costs are (1) transit operating costs, (2) the travel costs of those who use the facility, (3) the costs of road users on the roads upon which traffic conditions are influenced by the facility, and (4) the facility operating costs. The expected saving is calculated by making use of a with-and-without calculation.

Benefits for facility users (transit travellers) involve savings in generalised travel costs. As the opportunity cost of a transit service's vehicle operating costs is a transport operator's cost, it must not be added to travellers' fares in determining facility user costs. Only the non-monetary part of travellers' generalised travel cost is added to the transit operator's opportunity cost in determining the travel cost portion of the recurring costs of facility users.

A procedure to estimate the non-monetary portion of generalised costs of travelling with different modes of transport which move through passenger transport terminals and transfer facilities is detailed in the text.

The economic costs associated with creating a passenger transport terminal or a transfer facility are reflected in the opportunity costs of the initial investment (the so-called one-off cost) minus the discounted end value of the facility at the end of its service life. The facility will have an economic end value only if its remnants have an opportunity cost - i.e. if it can be used for alternative purposes.

A hypothetical example of an economic evaluation of a proposed passenger transport terminal is detailed in an appendix

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ATRF 96

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INTRODUCTION

The basic function of passenger transport terminals and transfer facilities is helping to ensure that passenger access to transit services, the flow of passengers on transit services and transfer between modes occur in an efficient, convenient, comfortable and safe way. The extent to which facility design and operation successfully carry out these basic functions, with consistent and continuous provision of services in an acceptable or pleasant environment, will determine the extent to which they are accepted by the travelling public.

DETERMINING ECONOMIC BENEFITS

Background

The use of passenger transport terminals which have been designed in terms of the above-mentioned objectives can hold benefits for (1) transit operators, (2) transit passengers (commuters), (3) users of streets adjacent to the facility, (4) the supplier of the facility, (5) the subsidizing government, and (6) the community/surrounding business district. The benefits to transit operators, transit passengers, adjacent street users and the subsidizing government are mainly of a transport economic nature and mostly involve savings stemming from the greater efficiency and effectiveness of the transport process. Benefits to the community/surrounding business district and the facility developer can in some cases entail "savings" in external costs (i.e. less exposure to negative external impacts such as pollution, noise, vibration and unsightliness, and non-transport economic benefits. Non-transport economic benefits do not involve savings but represent returns (profits) brought about by increased activities stemming from the investment in and operation of such facilities.

The economic benefit from the implementation and operation of passenger transport terminals and transfer facilities, which is included in an economic evaluation of these facilities, is equal to the saving this brings about in recurring costs. These costs are the transit operating costs, travel costs (excluding the travel fare) of transit passengers who use the facility, the costs for road users on the roads where the traffic conditions are influenced by the facility, and the operating costs of the facility. The benefits or savings in recurring costs offered by a new facility are calculated on the basis of a "with-and-without" situation.

The transit operator

The location of and distance between stops and the time spent in terminal and transfer facilities influence the efficient operation of public transport. The optimal placing of bus terminals offers the operator the benefit of a reduction in the number of non-revenue and low-income bus kilometres. This implies improved vehicle utilisation and lower vehicle operating costs.

The benefits for transit operators for application in an economic evaluation are therefore based on (1) the shorter distance that has to be travelled per vehicle (2) the more economic trip speeds attained (3) safer vehicle movement at the facilities and (4) less dwell time at the facilities.

Transit passengers

Recurring costs for users of buses and minibus taxis are a function of, among other factors, the value of travel time and the associated monetary costs to undertake a journey. The monetary cost component includes the fare paid as well as any other costs incurred to reach the destination. The latter are primarily applicable to park-and-ride facilities situated at passenger transport terminals and transfer facilities and include the running costs of the vehicle used to reach the destination.

The value of travel time is traditionally accepted as the product of the number of hours spent by the passenger to travel from point of origin to destination (walking, waiting, travelling and walking again) and the unit value of time. The value of travel time is linked to the purpose of the journey, the travellers' level of income and the amount of time saved per trip. Savings in travel time can accordingly be given a value by multiplying the selected unit value(s) of time by the amount of time saved. In the same way travel time including and not including the use of the terminal can be multiplied by the appropriate unit value(s) of time. The difference between the two products thus obtained is the value of time saved.

At the basis of any analysis of the demand for transport services is the fact that this demand is a derived function. With the possible exception of recreational journeys, road use as such does not normally contribute to the satisfaction of any need - people travel because they wish to do something at their destination. As transport therefore does not occur for the sake of the journey itself but is only a means to an end, there are accompanying sacrifices. These sacrifices, which present a resistance to the occurrence of a journey or accompaniment on a journey, may be called its disutility. The higher the level of disutility the less travellers would be willing to undertake trips. The components of this disutility are the following:

1. monetary cost (usually the travel fare in the case of transit journeys);

2. travel time (usually regarded as a sacrifice, or it has a negative value attached to it); and

3. negative qualitative aspects (for example discomfort and inconvenience endured, safety risks, exposure to frustration, unreliable service, walking times and waiting times at passenger transport terminals and transfer facilities).

The particular intensity or level of the experience of disutility is called generalised cost. The demand for transport is thus not simply dependent on travel costs or fares but in fact on the general associated opportunity costs. The generalised cost of a trip is expressed as a single, usually monetary, measure combining the important but disparate costs which form the overall opportunity costs of the trip. The characteristic of generalised cost is, therefore, that it combines all cost items to a single amount which is used in the same way as money costs are in standard economic analysis. The choice as to whether a journey is to be undertaken or not will be determined primarily by whether the generalised cost of the journey is regarded as greater or less than the utility a person may derive from being at the destination of the journey.

A commuter may perceive that trips to work by bus or train may be considerably more advantageous financially than car trips, but his personal bias against riding by bus or train may represent such a degree of disutility that the generalised cost of a car journey may be considerably lower than that for transit journeys. It is therefore clear that well-designed terminal and transfer facilities which function effectively, and with stops on their feeder routes which are optimally placed, will reduce the generalised cost of transit trips considerably and therefore increase commuters' willingness to travel by transit.

From the above generalised travel cost can be defined as the degree of perceived disutility, based on user sacrifices, that offers resistance to the undertaking of a journey or the selection of a particular mode by a traveller.

Comfort refers to the in-vehicle quality of service of a transport service. For example, passengers desire suitable sitting and standing space, ventilation and possibly air-conditioning. Congestion and an inadequate number of seats may be experienced as a disutility on longer commuter trips (when a passenger may have to stand for a long time in the vehicle). If congestion is also accompanied by a feeling of lack of safety or personal threat, the sense of disutility may be so intense that travellers resort to alternative forms of transport or even cancel the journey.

Whereas comfort refers to in-vehicle quality of service, convenience refers to the extra-vehicular standard of service of a transport system. The need to walk from one vehicle to another may be experienced as inconvenient, especially if a passenger has to wait for a long time for the arrival of the next transit vehicle. The more a passenger has to transfer and wait during unfavourable weather conditions without adequate shelter at the point of transfer, the more drastically the sense of inconvenience, and thus of disutility, will rise. Poor off-peak period services, insufficient system information, inadequate shelter at passenger transport terminals and transfer facilities, and a lack of parking space at these facilities can all be regarded as contributors to inconvenience. Although no commuter regards transferring as convenient, it can be accepted with certainty that if transferring is unavoidable, passengers will regard it as a lower cost penalty to transfer at a well-designed and sheltered facility which is functioning effectively and has relatively shorter vehicle headways than at an unsheltered and disorganised facility where the flow of vehicles is not smooth.

Convenience also has to do with the accessibility or availability of a transit system to its users. There are two facets to accessibility: in the first place it indicates the spatial proximity of a system's access points to the users' personal trip origins and destinations and, in the second place, the temporal frequency and headways between vehicles and the punctuality with which schedules are adhered to. Jointly the accessibility of transit components amounts to availability of services. The more available a service is in terms of the users' value judgements, the less it will be experienced as a disutility and the less it will contribute to generalised cost, and vice versa. A high level of accessibility or availability requires access points that are close by and an adequate frequency of service. It is unfortunately true that, due to cost limitations, there have to be continual compromises between the two components of accessibility. At the one extreme, for example, there could be a dense route network with a low service frequency (that is, access points close by but long vehicle headways) and at the other extreme a high-frequency service on a single route.

It is often argued that relative door-to-door travel time is a reliable substitute to represent the relative generalised cost users attach to services. Total door-to-door travel time could consist of five components: access, waiting, travelling, transfer and exit. The relative contribution of these periods to generalised travel cost varies as travellers experience them with different degrees of resistance or intensity of disutility. On the basis of this, multiplication factors may be used to weight walking, waiting, in-vehicle standing and transfer times to arrive at a generalised costs (see the time weighting factors recommended later in this section).

As the opportunity costs of vehicle operating costs are transit operating costs, it should be noted that these costs and travellers' fares are not added together in determining recurring costs. To avoid double counting only the non-monetary part of travellers' generalised travel costs is added to the opportunity costs of transit operators in determining the economic travel cost portion of recurring costs.

A model to assist in determining the non-monetary portion of generalised travel costs with different transit modes which move through passenger transport terminals and transfer facilities can be formulated as follows (Pienaar, 1995:30):

$$\text{NMGC} \quad = \quad \text{U}\left[\left(\frac{VT}{60}\right)+\left(\frac{A}{60}\right)(a-1)+\left(\frac{B}{60}\right)b+\left(\frac{C}{60}\right)c+\left(\frac{D}{60}\right)d\right] \quad \ldots\ldots(1)$$

where

NMGC	=	The average non-monetary part of generalised travel costs per transit passenger making use of the passenger transport terminal or transfer facility expressed in dollars.
U	=	Average hourly dollar value of time according to income group and trip purpose of travellers.
VT	=	The total in-vehicle travel time per person per journey, expressed in minutes. This includes the time spent in buses and/or minibus taxis as well as time spent in vehicles used to approach and depart from the terminal.
A	=	The total in-vehicle standing time per person per journey, expressed in minutes.
B	=	The walking time per person per journey, expressed in minutes. Walking time comprises the time needed by the passenger to walk from the point of origin to the terminal and from the terminal to the destination.
C	=	The waiting time per person during access, expressed in minutes.
D	=	The total transfer time per person, expressed in minutes.
a	=	Time weighting factor for in-vehicle standing time. (To avoid double counting with respect to variable VT, the value 1.0 is subtracted from a.)
b	=	Time weighting factor for walking time.
c	=	Time weighting factor for waiting time.
d	=	Time weighting factor for transfer time.

A procedure to assist in determining the non-monetary portion of generalised travel costs with different transit modes which move through passenger transport terminals and transfer facilities will broadly include the following:

A. Estimate the average total door-to-door travel time of the expected users of a system. In this process the following variables need to be researched: the actual location of the points of origin and destinations of prospective transit travellers who will use the passenger transport terminal or modal transfer facility; their average walking time during access (this is a function of walking distance to this facility and average walking speed); average waiting and transfer times at the facilities (the latter is a function of vehicle headways); travel time of modes; average in-vehicle standing times and average walking time during exit.

B. The calibration of factor weights whereby walking, waiting, in-vehicle standing and transfer times are weighted: these values will depend on, among other factors, the age, sex and income level of the passengers, and on climatic conditions. Gathering such information is done through project-specific investigation and questioning of potential passengers. If there is no opportunity for project-specific research, default values could be used based on the regional or average national attitudes of passengers which could in turn probably be ascertained through passenger panels. If there is no opportunity to research time weighting factors in this way during the planning and evaluation of passenger transport terminals and transfer facilities, the following unvalidated default values are recommended for time weighting factors:

Component of trip	**Time weighting factor**
Vehicle travel time (sitting) (VT)	1.0 (no weighting)
Vehicle travel time (standing) (A)	a : 2.0
Walking time during access and during exit (B)	b : 2.5
Waiting time during access (C)	
• at a well-designed and sheltered facility which functions effectively	c : 1.5
• at a partially sheltered facility functioning neither well nor poorly	c : 2.0

- at a badly designed and unsheltered facility which is relatively disorganised — c : 2.5

Transfer time (including waiting time) (D)

- at a well-designed and sheltered facility which functions effectively — d : 2.0
- at a partially sheltered facility functioning neither well nor poorly — d : 2.5
- at a badly designed and unsheltered facility which is relatively disorganised — d : 3.0

The above-mentioned default values are judgemental approximations by the author based on values through conducting an international literature search.

On the basis of various studies on this, Vuchic (1992:280) recommended that multiplication factors of 2.0 and 2.5 be used to weight walking time, waiting time and in-vehicle standing times in order to arrive at a generalised travel cost.

In a paper by Pienaar (1986) the generalised cost for users on different urban transport modes in South Africa was calculated by investigating the relative door-to-door travel times of commuters in different transit vehicle classes. Walking times at route terminals and waiting times at transfer points were both multiplied by a factor of 2.0. (The assumption was that travellers' generalised cost of walking and waiting time is double that of in-vehicle travel time.)

According to the MVA Consultancy (1994:263) the British Department of Transport recommends that walking and waiting time should be valued double that of in-vehicle time.

Ortúzar & Willumsen (1990:262) are of the opinion that walking and waiting time during access, transfer time and exit time must be weighted with factors which vary in value between 2.0 and 3.0.

According to AASHTO (1977:105) and the ECMT (1973:60) the value placed on walking and waiting times is usually 1.5 or 2.0 times the in-vehicle travel time per person per hour. This value can be higher in cases where the quality of extra-vehicular convenience and safety is poor.

The factors whereby time is weighted usually vary between 1.5 and 3.0 with increments of 0.5 between them. A factor of 1.0 indicates no weighting while a factor of 3.0 usually indicates the highest degree of disutility.

The users of streets adjacent to the facility

The creation of an off-street passenger transport terminal will lead to an increase in the normally limited availability of street space. This could result in freer traffic flow, especially if there are also sound traffic control arrangements in the immediate vicinity of the facility.

Improved traffic flow offers road users the benefit of savings in travel time and vehicle running costs. The freer traffic flow could also lead to a reduction in the risk and costs of accidents.

The government institution/facility developer

In cases where the transport authority or other property developer involved in the operation of a terminal also makes the property available for commercial activities, income from rent is derived as a financial benefit. Yet it should be borne in mind that the possible financial returns from business activities at a terminal or transfer facility should not be included as an economic benefit in an economic evaluation of these facilities. The rental from businesses and the returns realised by traders at such facilities and amenities have nothing to do with the economic sources sacrificed in the transport process. In the first place, these financial returns do not reduce the opportunity costs of the public transport process. In the second place, it can be accepted that the business activities at such facilities would in any event occur elsewhere because the travellers are not captive buyers (and thus make their purchases voluntarily) and therefore do not enhance the economic welfare of the community. However, travellers can save time and a possible trip if shopping is done at a transfer facility. In cases where such savings are expected to materialise, their value must be included in the analysis.

Transit operators who use effective terminal facilities can bring about savings in vehicle operating costs. Such savings can be expressed as lower fares and/or savings in the subsidy expenditure of the regulating or subsidizing government institution. But it must be remembered that subsidy savings must not be included as an additional economic benefit in the economic evaluation of the facilities. The reason for this is that the saving in transit operating cost has already been included as an opportunity cost saving in the calculation in the economic evaluation and benefits will be counted twice if a reduction in subsidy obligations is also included.

Non-transport economic benefits

Non-transport economic benefits do not involve savings but represent a group of plus-factors or returns which are partly the consequence of incentives and investments in other sectors of the economy. They can be seen as general economic benefits, above and beyond the direct transport benefits, that contribute to the welfare of everyone within the geographical sphere of influence of the facility. The non-transport economic "benefits" of a transport facility usually amount to a transfer of economic activities (which would have taken place elsewhere anyway) to the location or vicinity of the transport facility. The extent to which general economic benefits can be ascribed to the provision and operation of a new transport facility is determined by the extent to which accessibility and mobility are increased and facilitated. The latter are directly expressed in transport cost savings -that is, those savings accruing to the transit operator, transit passengers, users of streets adjacent to the facility and the subsidizing authority.

Seeing that an increase in non-transport economic benefits is nothing more than a spatial transfer or distribution of returns which would in any event have been realised elsewhere, these apparent benefits are not credited to a transport facility in an economic evaluation. It must be remembered that additional investment (above and beyond that necessary for the terminal or transfer facility) is a prerequisite for the realisation of non-transport economic benefits. The additional income stemming from the multiplying effects of investment in a terminal, and any increase in commercial activities stemming from the later operation of such a facility, are therefore not taken into account in the economic evaluation of these facilities.

DETERMINING THE COST COMPONENT FOR USE IN ECONOMIC EVALUATION

It was indicated previously that in economic evaluation recurring costs form the basis for calculating benefits. As opposed to this the opportunity cost of construction (the so-called one-off cost, which represents the capital investment amount) is the cost component in economic evaluation).

The opportunity costs of construction include the costs incurred in direct planning (traffic surveys, studies of bus and taxi use and establishing a facility, environmental impact studies, etc.), the direct costs of designing the terminal, the acquisition and development of the site (demolishing, levelling, reinforcement, etc.) and the construction of the terminal (including the construction of access roads). Each item includes the opportunity costs for materials used, wages paid and operating and overhead equipment bought - in fact the actual scarcity value of all inputs which are inevitably needed to create the facility (that is, to supply it complete and ready for transit operation). Care must be taken to include in the analysis only the costs of that part of the facility which is necessary for the functioning of the terminal and the transfer facility for transit purposes. Spaces which are used for commercial activities and entertainment, for example, are non-transport economic considerations and the costs associated with them are left out of the evaluation. It is recommended that the evaluator makes use of the service of a quantity surveyor to compile a complete quantity survey for the construction of the facility to determine the additional costs caused by the non-transport related amenities. In this way it can be ascertained whether the initial cost estimates must be adapted to reflect the opportunity cost more accurately.

CONCLUSIONS

The economic benefit stemming from the construction and operation of passenger transport terminals and transfer facilities is equal to the savings it brings about in recurring costs. These costs are the travel costs of those who use the facility, transit operating costs, the costs of road users on the roads upon which traffic conditions are influenced by the facility, and the facility operating costs. The expected saving is calculated by making use of a with-and-without calculation.

Benefits for facility users (transit travellers) involve savings in generalised travel costs, which include:

* monetary costs (the transit fare paid as well as the taxi tariff paid or the running costs of the private vehicle used to reach the terminal);

* travel time; and

* negative quality aspects (discomfort and inconvenience endured, safety risks, exposure to frustration, service unreliability, and walking, waiting and transfer times at terminals and transfer facilities).

As the opportunity cost of a transit service's vehicle operating costs is a transport operator's cost, it must not be added to travellers' fares in determining facility user costs. Only the non-monetary part of travellers' generalised travelling cost is added to the transit operator's opportunity cost in determining the travel cost portion of the recurring costs of facility users.

For road users the creation of an off-street passenger transport terminal or transfer facility results in an increase in the normally limited amount of street space. This can lead to a smoother traffic flow if it is accompanied with sound traffic control arrangements in the immediate vicinity of the facility. Improved traffic flow offers road users the benefit of savings in travel time, vehicle running costs and a reduction of accident risks and costs.

The economic costs associated with creating a passenger transport terminal or a transfer facility are reflected in the opportunity costs of the initial investment (the so-called one-off cost) minus the discounted end value of the facility at the end of its service life. The facility will have an economic end value only if its remnants have an opportunity cost - i.e. if it can be used for alternative purposes.

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APPENDIX 1

EXAMPLE OF AN ECONOMIC EVALUATION OF A PROPOSED PASSENGER TRANSPORT TERMINAL

PROPOSED PROJECT

A badly designed and unsheltered passenger transport terminal is to be replaced by a well designed and sheltered terminal facility. The old (existing) terminal facility is located partially on-street and this disrupts passing traffic, while its poor layout leads to delays of buses and minibus taxis making use of it. The planned facility will be located off-street which will lead to smoother flow of traffic on the adjacent street, while the dwell time of buses and minibus taxis at the new facility will decrease. The terminal is at the end of all bus and minibus taxi routes, which implies that all passengers transfer, end or start their transit journeys there. (There are no through-travelling passengers who remain on board vehicles.)

An economic evaluation of the proposed terminal needs to be performed by calculating the present worth of costs of the existing and proposed facility, and the net present value, the benefit/cost ratio and the internal rate of return of the proposed facility. The following input values and assumptions are supplied:

1. Should the project go ahead, the site on which the facility is to be erected will be withdrawn from alternative use at the end of year 1. (At the moment it is year nil.) The local transport authority, which will own and operate the facility, has the option to purchase the site for $3 000 000. The authority's land assessors judge that this amount reflects the site's opportunity costs.

2. All the needed planning and design of the facility will take place throughout year 1 and the costs of this will amount to $1 200 000 in economic terms.

3. The facility will be erected during year 2 at a fully competitive market price of $43 150 000. This amount includes value added tax of $3 150 000.

4. The facility will have an expected service life of 25 years and it must be evaluated over its entire expected service life. This period commences at the beginning of year 3. At the end of the service life the facility will be completely obsolete. The site is being paid for with Reconstruction and Development Programme funds and therefore the transport authority has pledged to the community that the site will always be used as an access node to public transport.

5. The estimated direct recurring costs (i.e. operating, maintenance and policing costs) of the proposed facility will remain constant at $700 000 per annum. The direct recurring costs of the existing facility amount to $100 000 per annum. Both these costs are in economic terms.

6. The total economic costs of traffic disruption and congestion imposed on adjacent street traffic by the presence of the existing facility amount to $375 000 per annum; these costs will be eliminated if the proposed facility is built and may be regarded as an indirect recurring opportunity cost of the existing facility.

7. Due to the expected improved traffic flow on the adjacent street and the opportunity for freer and orderly vehicle and passenger movement within the new facility, the arrival and departure times of buses and minibus taxis will be more predictable. This improved punctuality and shorter travel times will result in that each bus and minibus which uses the facility completing one additional trip per day, thereby also reducing the average time headway between vehicles. This will not only reduce waiting and transfer times of passengers, but also enable the transit services to carry more passengers, while still reducing the need for some of them to stand in the buses. Regardless of the fact that each transit vehicle will complete one extra trip per day, the total opportunity costs of the bus and minibus operators will, because of increased efficiencies created by the new facility, decline by $30 000 per annum. These annual amounts of $30 000 each include indirect taxes of $5 000. (These savings may be regarded as recurring additional transit operating costs associated with the existing facility.)

8. Owing to the improved quality of service and greater safety and security that will emanate from usage of the proposed facility, the existing average annual patronage of the transit services is expected to increase from 2 500 000 passengers to 2 625 000 passengers with the proposed facility.

9. At present the average travel fare by bus and minibus taxi amounts to $1.50 per single trip (which is the price of the travel ticket to the user). To this amount a central government subsidy of $0.50 (per single trip) is added so that the bus and minibus taxi operators receive $2.00 per single passenger journey. The market is split evenly between the bus and the minibus taxi operators, and the total revenue that they receive exactly covers their opportunity costs.

10. In order to calculate the non-monetary part of generalised travel costs of transit passengers (NMGC), equation and time weighting factors supplied with this formula are used. (Due to the fact that site-specific time weighting factors were not determined by the local authority, the default values proposed in the text are to be used as time weighting factors.) With respect to the other variables in the NMGC formula, the following values apply:

Variable	Existing facility	Proposed facility
U	5.00	5.00
VT	25	21
A	4	2
B	15	15
C	10	6
D	10	6

(Over and above the non-monetary generalised travel cost of the existing users, the consumer surplus or benefit that will accrue to generated trips may be regarded as an opportunity cost caused by the inefficiency of the existing facility which is eliminated by the efficiency of the alternative or proposed facility.)

ANALYSIS

Calculation of capital costs (the one-off costs) in year nil values

To obtain the present worth (PW) of the investment costs, the value of the site, and planning and design costs need to be discounted for one year (i.e. be divided by 1.08), while the construction costs need to be discounted for two years (i.e. be divided by 1.08^2).

1. PW of site value: \$3 000 000/1.08 = \$2 777 778

2. PW of planning and design costs: \$1 200 000/1.08 = \$1 111 111

3. PW of construction costs: (\$43 150 000 - \$3 150 000)/1.08^2 = \$34 293 553

   (Value added tax is deducted to arrive at the shadow price of construction)

4. Due to the fact that the facility is expected to be completely obsolete at the end of its service life and that it is not foreseen that the site will be made available for alternative use, no terminal value is assigned to the proposed project.

PW of capital costs is therefore the sum of the above values = \$38 182 442

Calculation of benefits in year nil values

To obtain the PW of the benefits of the proposed project, the recurring costs of each facility during the service life of the proposed facility (i.e. beginning year 3 to end of year 27) must be discounted to year nil. The PW of the recurring costs of the proposed facility is then deducted from the PW of the recurring costs of the existing facility.

It is given that all the recurring costs of both facilities will remain constant (i.e. uniform) per annum throughout the service life of the proposed facility. To discount the two series of annual amounts which occur from the beginning year 3 to the end of year 27, the annual costs of each alternative need to be multiplied by the uniform series present worth factor. The uniform series present worth factor at an annual discount rate of eight percent over 25 years = 10.674 776. The two single amounts thus obtained represent beginning year 3 (= end year 2) values and must still be discounted for two years, i.e. divided by 1.08^2 to obtain their year nil values.

5. PW of direct recurring costs of the existing facility:

   = \$100 000 x 10.674 776/1.08^2 = \$915 190

   PW of direct recurring costs of the proposed facility:

   = \$700 000 x 10.674 776/1.08^2 = \$6 406 330

   Saving of direct recurring costs with the existing facility:

   = \$915 190 - \$6 406 330 = -\$5 491 140

6. PW of indirect recurring costs of the existing facility (traffic congestion on the adjacent street):
= $375 000 x 10.674 776/1.08^2 = $3 431 962 (This amount is automatically a benefit (saving) with respect to the proposed facility.)

7. PW of additional user costs resulting from the inefficiency of the existing facility:
= ($30 000 - $5 000) 10.674 776/1.08^2 = $228 797 (This amount is automatically a benefit (saving) with respect to the proposed facility.)
Note: The indirect taxes of $5 000 are subtracted from the annual saving of $30 000 in order to obtain its shadow price.

8. There are 2 500 000 existing transit users for whom the annual non-monetary savings in generalised costs are determined by using the "NMGC" formula (equation 1). There are 125 000 generated transit trips of which the benefit per passenger is represented by their generated consumer surplus.

   On the assumption that the demand schedule of the transit users is represented by a linear function between generalised cost and number of trips, the average benefit obtained per generated transit passenger trip is equal to 0.5 of the saving per existing transit passenger trip.

9. The passenger travel fare and subsidy granted are not taken into account in the economic evaluation as this will amount to double counting them with the vehicle operating costs of the transit operators.

10. The annual non-monetary component of the existing 2 500 000 passengers' generalised cost with the existing facility:

$$= 2\,500 \times 1\,000 \times \$5 \left[\left(\frac{25}{60}\right) + \left(\frac{4}{60}\right)(2-1) + \left(\frac{15}{60}\right)2{,}5 + \left(\frac{10}{60}\right)2{,}5 + \left(\frac{10}{60}\right)3{,}0 \right]$$

= $25 312 500
(PW of $25 312 500 = $25 312 500 x 10.674 776/1.08^2 = $231 657 465)

The annual non-monetary component of the existing 2 500 000 passengers' generalised cost with the proposed facility:

$$= 2\ 500 \times 1\ 000 \times \$5 \left[\left(\frac{21}{60}\right) + \left(\frac{2}{60}\right)(2-1) + \left(\frac{15}{60}\right)2{,}5 + \left(\frac{6}{60}\right)1{,}5 + \left(\frac{6}{60}\right)2{,}0 \right]$$

= \$16 979 167

(PW of \$16 979 167 = \$16 979 167 x 10.674 776/1.08² = \$155 391 636

The annual saving of non-monetary generalised trip costs of the existing passengers:

= \$25 312 500 - \$16 979 167 = \$8 333 333

Therefore the annual benefit for the generated passengers:

= 0.5 (\$8 333 333/2 500 000) 125 000 = \$208 333

(PW of \$208 333 = \$208 333 x 10.674 776/1.08² = \$1 906 643)

PW of the annual benefits as a result of the decrease of non-monetary generalised cost:

= (\$8 333 333 + \$208 333) 10.674 776/1.08² = \$78 172 472

The total benefit of the proposed facility expressed as a year nil value:

= -\$5 491 140 + \$3 431 962 + \$228 797 + \$78 172 472 = \$76 342 091

Application of evaluation techniques

(i) PWOC existing facility = \$915 190 + \$3 431 962 + \$228 797 + \$231 657 465 + \$1 906 643 = \$238 140 057

(The PWOC of the existing facility is the sum of the costs under items 5, 6, 7 and 10.)

PWOC proposed facility = \$38 182 442 + \$6 406 330 + \$155 391 636 = \$199 980 408

(The PWOC of the proposed facility is the sum of the costs under items 1, 2, 3, 5 and 10.)

(ii) NPV = \$76 342 091 - \$38 182 442 = \$ 38 159 649

(The NPV of the proposed facility is equal to its total benefit minus its investment or capital cost. Alternatively stated the NPV = PWOC existing facility - PWOC proposed facility.)

(iii) B/C Ratio = \$76 342 091/\$38 182 442 = 2.0

(The B/C Ratio of the proposed facility is equal to its total benefit divided by its investment cost.)

(iv) IRR = 18%

Discount rate per annum	Year nil values with selected discount rates		
	Investment cost	Returns	Difference or "NPV"
17	\$32 810 286	\$35 137 700	\$2 327 414
18	\$32 286 699	\$32 751 438	\$ 464 739
19	\$31 776 005	\$30 602 492	-\$1 173 513

(The IRR is that discount rate at which the returns or benefits equal the investment amount. Alternatively stated it is that discount rate at which NPV = 0)
A discount rate of 18 percent is the full percentage that comes closest to equalising the two quantities.

Due to the fact that the NPV > 0, the B/C Ratio > 1.0, the IRR > official discount rate and that PWOC proposed facility < PWOC existing facility, the proposed facility is economically justified.