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TRANSPORT NOTES

TRANSPORT ECONOMICS, POLICY AND POVERTY THEMATIC GROUP

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Notes on the Economic Evaluation of Transport Projects

In response to many requests for help in the application of both conventional cost benefit analysis in transport and addressing of the newer topics of interest, we have prepared a series of Economic Evaluation Notes that provide guidance on some of issues that have proven more difficult to deal with.

The **Economic Evaluation Notes** *are arranged in three groups. The first group (TRN-6 to TRN—10) provides* **criteria** *for selection a particular evaluation technique or approach; the second (TRN-11 to TRN-17) addresses the selection of values of various* **inputs** *to the evaluation, and the third (TRN-18 to TRN-26) deals with specific* **problematic issues** *in economic evaluation. The Notes are preceded by a* **Framework** *(TRN-5), that provides the context within which we use economic evaluation in the transport sector.*

The main text of most of the Notes was prepared for the Transport and Urban Development Department (TUDTR) of the World Bank by Peter Mackie, John Nellthorp and James Laird, at the Institute for Transport Studies (ITS) , University of Leeds, UK (The draft text of Note 21 was prepared for ITS by I.T. Transport Ltd). TUDTR staff have made a few changes to the draft Notes as prepared by ITS.

The Notes will be revised periodically and we welcome comments on what changes become necessary. Suggestions for additional Notes or for changes or additions to existing Notes should be sent to rcarruthers@worldbank.org

SOURCES OF OPERATING COSTS

Historically, road vehicle operating costs have tended to dominate highway economic appraisals in developing countries due to the poor road surfaces that can occur there. The operating costs of railways and ports are also substantial and form key components of cost benefit analyses of their associated infrastructure. The definition of operating costs for World Bank projects is therefore important in obtaining a reliable economic appraisal.

Section 1 introduces the key issues associated with operating costs, whilst the following sections discuss the components and sources of operating costs by mode. Road vehicle operating costs are presented in Section 2, railway operating costs in Section 3 and port operating costs in Section 4.

OPERATING COSTS KEY ISSUES

Costs accrued during the functioning of the transport infrastructure are borne by:

- Users (e.g. vehicle drivers/passengers where they are the owners of the vehicle they are travelling in and ships whilst in port)
- Service providers (e.g. the operators of public transport services (e.g. rail service) or the owners of vehicles driven by others (e.g. road haulage firm)).
- Infrastructure "Landlord" or owner

This note concerns the first two (i.e. users and service providers). The costs borne by the infrastructure owner or landlord are described in *TRN 13: Treatment of Maintenance.*

Operating costs can be influenced by the regulatory and institutional characteristics of the environment in which the transport industry in a particular country sits. This is particularly the case for the rail, shipping and air sectors. Local country specific data and relationships on operating costs for these sectors should therefore be utilised wherever possible, though in many cases the availability of such data will depend upon the accounting practices within that sector (country specific). Operating cost relationships for road vehicles are far more generic and transferable between countries. Off the shelf models and computer software exists for the calculation of such road vehicle operating costs, however, these models require to be populated with some local data.

Operating costs are also influenced by the transport infrastructure maintenance strategy particularly in areas subject to periodic environmental shocks (e.g. a wet season). If transport infrastructure is not maintained operating costs can increase significantly. Operating cost calculations should therefore reflect the infrastructure maintenance strategy *(see TRN 13: Treatment of Maintenance).*

In some situations, particularly regulated sectors, the infrastructure landlord and the service provider are the same body (e.g. a nationalised railway network or a port authority). In other situations the infrastructure landlord and the service provider maybe separate bodies but the service provider may pay the landlord for access to the infrastructure on variable basis (e.g. for trains on a per km of track travelled). This payment by the service provider would include a component for the maintenance of the infrastructure, but from the point of view of the service provider would be considered an operating cost of the service. In such situations it may be difficult to distinguish between operating and maintenance costs and it may be easier to consider the two simultaneously, ensuring however that there is no double counting.

In the case of all economic appraisals of transport investment projects the key input with respect to operating costs is the change in operating costs with and without the project. However, the nature that this change is brought about will determine whether an incremental or absolute operating cost model is required.

- **An incremental model** will be sufficient for majority of situations that will be assessed as part of a World Bank funded project. Within an incremental model it is expected that unit costs of operation will not alter significantly after the investment.
- **An Absolute Model:** would be required where the unit costs of operation are expected to alter significantly after the investment. Examples, would include the replacement of a significant percentage of the bus vehicle fleet or some form of regulatory reform occurring simultaneously with the investment (such as privatisation or commercialisation). In such a situation a full understanding of the existing operating cost structure of the sector will be required as well as any efficiency improvements that the reform may bring about.

Operating costs accrue throughout a project's life and as such should reflect the manner that resource costs will vary during the lifetime of a project. Consideration will need to be given to the derivation of future year resource costs. Comparability should be maintained with the assumptions regarding other future year costs (e.g. value of time and accident costs, see *Framework)*.

ROAD VEHICLE OPERATING COSTS

Operating costs for road vehicles comprise of those incurred by road users and road service providers (e.g. road haulage firm). The nature of these costs is that they are distance dependent, however, some vary linearly with distance travelled (e.g. fuel costs) whilst others vary in a step like or lumpy manner (e.g. vehicle purchases and maintenance schedules). The principle components of road vehicle operating costs are detailed in Table 1:

Table 1. Components of Vehicle Operating Costs and their Relative Contributions

Component	Percentage Contribution	
	Private Cars	Trucks
Fuel	10-35	10-30
Lubricating Oil	<2	<2
Spare parts	10-40	10-30
Maintenance (labour)	<6	<8
Tyres	5-10	5-15
Depreciation	15-40	10-40
Crew costs	0	5-50
Other costs and overheads	10-15	5-20

Source: "A guide to Road Project Appraisal," Overseas Road Note 5, Overseas Development Administration, 1988, p51 [i]

These costs vary by vehicle type, the condition of the road surface and vehicle speed. Road vehicle operating costs are therefore correlated with the proposed road design standard (e.g. bitumen, concrete or gravel surface), the road maintenance strategy, environmental impacts, the composition of the traffic flow and road congestion (through speed).

The Highway Design Model Vehicle Operating Cost (HDM VOC) [ii] [iii] model contains predictive relationships for the above factors and is recommended for World Bank funded road projects. It should be noted that such a model is incremental in nature. Thus should the scale of the project under consideration represent a step change in the scale of say bus public transport or road haulage (e.g. a doubling or trebling of the fleet size) the model will not fully reflect the costs of the structural change that will occur within the sector. Additionally, this model will not be able to reflect the nature of regulatory or structural reform in either the bus sector or the road haulage sector.

HDM4 allows the definition of both motorised vehicles (MVs) and non-motorised vehicles (NMVs). Operating costs for all vehicle types should be included within the assessment, including those associated with NMVs particularly for rural roads and low volume roads *(see Note 16 Low Volume Roads).* The following local data will be required to populate the HDM4 vehicle operating cost model (source Further Reading reference [i]):

Road Characteristics

- Rise (m/km)
- Fall (m/km)
- Curvature (degrees/km)
- Roughness (m/km)
- Road width (metres)
- Surface moisture content for gravel and earth roads (percent)
- Rut depth

Vehicle Characteristics

- Free speed in environment under consideration (km/h)
- Vehicle weight (tonnes)
- Power to weight ratio (bhp/tonne)
- Vehicle age (km, yr)
- Vehicle price
- Tyre price

- Price of fuel and lubricants (per litre)
- Price of maintenance labour (per hr)
- Vehicle crew costs (per hr)
- Overheads

Climate

- Rainfall (mm/year)

Overseas Road Note 5 (reference [i]) defines the data that are required for each of the above local variables. Wherever possible these should be surveyed or obtained from reliable sources (e.g. maps or the regional or central government). In some situations a pragmatic approach may have to be utilised, drawing on data from other countries to provide an estimate for the study area under consideration. With respect to Non Motorised Vehicles (NMVs) a worked example of operating costs is provided in DFID (200?) [iv] and Lebo and Schelling (2001) [v].

Note that vehicle crew costs include crew wages. Care is therefore needed to avoid double counting of this component with the Time values, both in modelling and in appraisal.

RAILWAY OPERATING COSTS

The operating costs for a railway are those incurred by the service provider. These costs vary as follows:

- Between freight and passenger services
- By the type of freight carried. If the freight is high volume low density than the cost per tonne will be higher than if it is low volume high density (operating costs vary by the number of cars used per train and there maybe weight restrictions that limit freight train sizes).
- By the length of the journey (costs per mile decline with distance)
- By track alignment (it takes more power and fuel to climb mountains than it does to cross flat country)
- By operational characteristics (a returning empty freight train costs less per mile than a full outbound train)

The operating costs will also reflect the physical characteristics of the rail network (including say depot locations) and the regulatory and labour market framework.

Operating costs for railway systems will include the following items, comprising both standing (or time-dependent) costs, which do not vary with distance travelled, and distance-dependent costs:

Standing Cost Components:

- Depreciation (time-dependent share)
- Repair and Maintenance Costs

Distance-Dependent Components:

- Overheads
- Administration
- Operating cost components:
- Personnel Costs (that is, costs associated with bus and coach drivers, and the crew of trains, ferries and passenger aircraft)
- Depreciation (distance-related share)
- Fuel and lubricants

Note, as with road vehicles, "Personnel Costs" include drivers' wages and care is therefore needed to avoid double-counting of this component with the Time values, both in modelling and in appraisal.

The nature of these operating costs is that they are variable and generally distance related. Some of the cost items are "lumpy" such as replacement costs for locomotives whilst others are proportional to distance (e.g. train fuel costs). Table 2 details the some sources of unit costs for the components identified above.

Table 2. Variable Railway Operating Costs

Cost Type	Operating Cost
Vehicle Ownership Costs	
Locomotives	Replacement Cost
Freight cars	Replacement Cost
Coaches	Replacement Costs
Vehicle Maintenance Costs	
Locomotives	Unit cost/loco unit-km
	Unit cost/litre of fuel used
Freight cars	Unit cost/car-km
	Unit cost/carload
Transportation Costs	
Train fuel	Unit cost (gross ton-km)
Train crew wages	Actual by cost centre
Loco crew wages	Actual by cost centre
Shunting	Unit cost/shunting per minute
Station operations	Unit cost/train-km
Billing	Unit cost/carload
Other	Unit cost/train-km

Source: Anderson, P., Understanding the Costs of Commercial Railways, Transport Infrastructure Note RW-10, World Bank, Washington DC, USA. [vi]

The estimated unit costs in Table 2 will vary according to the characteristics of the railway network under consideration. Unit costs will reflect the following:

- Congestion effects: should the railway under consideration operate at or close to capacity in certain locations delays maybe experienced within the system. Utilisation rates for the train vehicles will therefore decrease as delays increase thereby increasing unit costs.
- Operational characteristics or regulatory framework: the method of operation maybe considered to be inefficient for whatever reason. This will affect train vehicle utilisation rates amongst others and thereby average unit costs.

Railway operating costs are therefore country specific. Local cost data is essential for a reliable estimate of the change in operating costs brought about by a transport investment. Should the accounting systems for the railway under consideration not distinguish between these operating cost items or even between maintenance and operating costs the following approach could be adopted:

- Directly assign actual expenses to actual operations, where possible.
- Analysis of the "revenue" or "current" account to identify the manner that revenue expenditure has altered historically with train operations (time series analysis). Or if the accounts distinguish between different geographical areas cross-sectional analysis of the revenue accounts by train operations.

Railway operating cost models derived in such a manner contain an implicit assumption that the cost base will not be affected by the transport investment proposed. The following situations, however, may result in a change in the cost base:

- The use of a new type of locomotive with unknown operating costs and reliability (an engineering unit cost may have to be used)
- A step change in the level of service provision at a regional level (congestion effects maybe incurred and new infrastructure with different utilisation rates maybe required)
- Railway reform (e.g. privatisation or commercialisation) may alter the cost base.

PORT OPERATING COSTS

As with road vehicles and railways, port operating costs relate to the cost of providing the service (at the port). However, the operating costs of ports differ from those of road vehicles or railways as they are borne by three groups of operator:

- The port operator;
- The ship operator whose ship is waiting to unload and be loaded. The ship operator's costs may also be affected by the maximum ship size that can be accommodated within the port (i.e. ship operating costs could be reduced through ship size (economies of scale) if port capacity allowed it); and
- The importer or exporter who is either waiting for their goods or is waiting to load their goods (e.g. costs of continuing refrigeration of perishables)

A detailed understanding of the cost structures in the above three groups is required for the analysis of changes in port operating costs.

FURTHER READING

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i Overseas Road Note 5 (1998) A guide to Road Project Appraisal, Overseas Development Administration, Chapter 10 [Available on-line at http://www.transport-links.org/transport_links/]

ii Archondo-Callao, R.S. and Faiz, A., (1994), Estimating Vehicle Operating Costs. World Bank Technical Paper Number 234, The World Bank, Washington DC, USA. [Available on-line at http://www.worldbank.org/transport/publicat/wbtp-234.pdf]

iii PIARC (2002) The Highway Development and Management Model (HDM4), [Documentation and Software available on line http://hdm4.piarc.org/]

iv Department for International Development (DFID), UK (200?), DFID Economist Guide, HMSO (?) [Available online at http://www.transport-links.org/Economist Guide/English/Intro.htm]

v Lebo, J. and Schelling, D. Design and Appraisal of Rural Transport Infrastructure, TWU-45 Report, The World Bank, Washington DC, USA.

vi Anderson, P., Understanding the Costs of Commercial Railways, Transport Infrastructure Note RW-10, World Bank, Washington DC, USA. [Available online at: http://www.worldbank.org/transport/publicat/td-rw10.htm]