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Measuring Road Transport Performance

1. Aspects of Performance

To a large extent the bottom line indicator of performance of freight and passenger road transport is the operating cost per tonne or tonne-km (or per passenger or passenger-km). Level of service aspects such as travel time, reliability, safety, comfort and security are also important, as well as environmental impacts.

Trucks: In countries where large-scale intercity trucking operates efficiently in medium-income countries with predominantly flat terrain, recent experience is that the transport cost per km for a truck-trailer is between US$0.75 and US$ 1.25. For a typical load of 20 tonnes, this works out at US cents 4-6 per tonne km. By contrast efficient small-scale transport in rural areas using small trucks may have a cost of US$ 0.20-0.30 per tonne-km, although it is common for the rates to be expressed on an hourly rather than km basis. Inefficient operations may push these costs much higher.

Main factors that affect trucking costs are

- economies of scale in truck size, which favor the use of larger trucks,
- back-haul possibilities, which depend strongly on the demand pattern,
- empty running and idle time due to seasonal variations in demand,
- restrictions on working hours, for example due to regulations or safety reasons,
- road conditions such as mountainous terrain, deteriorated pavement and traffic congestion,
- enforcement procedures along the road and at border posts, which can delay trucks and impose high unofficial payments,
- standard of trucks, in terms of design and condition, which affects speed, availability and consumption rates for fuel, spares and other inputs,
- availability of freight forwarding and other services, which is often poor in remote areas,
- quality of service offered (specialized freight services may involve higher costs),
- input or factor prices of labor, vehicles, spares and fuel, which may vary with tax/subsidy policies and other locational factors,
- quality of management, which affects many important aspects of staffing practices and the way equipment is used (often associated with whether or not the operator is state-owned or privately-owned).

While cost is usually the single most important aspect of trucking services, customers also attach importance to speed, door-to-door deliveries, avoiding damage to or theft of goods, and predictability of delivery time.

Buses: For large good-quality non-airconditioned long-distance buses operating efficiently in medium-income countries, operating costs of about US $ 0.40 per km can be achieved. With an average load of about 40 passengers this corresponds to a bus fare of about US cents 1.0 per passenger-km. Small-scale basic quality minibus services in rural areas can offer similar fares, operating efficiently with high, even passenger flows. However, fares in rural areas can be about double this due to higher costs attributable to poor roads and mountainous terrain, serving small or variable numbers of passengers.

The main factors that affect bus costs are similar to those listed above for trucks. In particular they include:

- demand pattern, which varies in time and place and constrains scheduling possibilities,
- quality of service offered, such as availability of seats, predictability of services, comfort and whether or not special features such as air conditioning are provided,
- extent of competition, related to type of regulation and amount of collusion among operators.

Bus passengers often attach similar importance to level of service as to fares, especially travel time (including access and waiting times, which are affected by service frequency and reliability of services). They may also value the type of seating and whether or not air conditioning is fitted.

2. Factors Affecting Trucking Performance

As indicated above, trucking costs are strongly dependent on vehicle productivity and prices of inputs such as fuel, vehicles and spare parts. Productivity varies in turn with factors such as distance of hauls, vehicle size and specifications, consignment size and nature, road conditions, and demand pattern. Input prices vary with country, because of characteristics of transport enterprises and support industries (state-owned enterprises may receive subsidies of some sort), national economic characteristics and tax regimes. An example of a comparison of trucking costs is described in Rizet C. and Hine J. L. "A comparison of the costs and productivity of road freight transport in Africa and Pakistan", Transport Reviews, Vol. 13, No. 2, 151-165, 1993. This study showed how costs per tonne-km reduce sharply with increasing distance and consignment size and that a variety of factors can produce markedly different costs between countries. More information on this publication may be found at the Taylor & Francis Publishers Web site.at http://www.tandf.co.uk/journals/frameloader.html?http://www.tandf.co.uk/journals/tf/01441647.html.

To investigate key factors that may affect operating costs and level of service, it is useful to

- examine the proportion of costs incurred under each item such as fuel and spares, in relation to prevailing input prices,
- measure a variety of performance indices in relation to those expected for efficient operation, and
- analyse problems that affect performance, and their effects.

2.1 Cost Breakdown

For many efficient trucking operations the typical proportion of operating costs found for each item is as shown below (for operations in low- and medium-income countries).

Cost Item	Proportion of Operating Cost (%)
Variable Costs	
Fuel	20 – 30
Lubricating Oil	1 – 5
Tires	10 – 15
Spares	15 – 20
Fixed Costs	
Driver and other cab staff	10 – 20
Other Labor	About 5
Depreciation and Interest	15 – 20
Overheads and other costs	10 – 15
TOTAL	100

Expected costs can be estimated relatively easily for some items. For example, fuel consumption for modern trucks varies between about 30 liters per 100 km for a medium truck (seven-tonne payload) up to about 60 litres per 100 km for a heavy truck-trailer (20-tonne payload). The number of staff per truck should be no higher than two or three (depending on whether only one driver is assigned to each truck or if more than one driver work shifts on the same vehicle). Many other cost items can only be estimated by analysing operating and expenditure data.

2.2 Measuring Performance

Vehicle utilization (vehicle-km per year) strongly affects the balance between fixed and variable costs and gives an important overall indication of efficiency. Higher than expected proportions of fixed costs could indicate utilization much less than 100,000 km per truck, a figure which is certainly possible for efficient operation on long hauls.

Often low utilization indicates low efficiency due to factors such as

- poor condition of roads due to inadequate maintenance,
- poor condition of vehicles, resulting perhaps from excessive numbers of old or obsolete trucks, poor driving methods and/or maintenance,
- poor operational practices (such as not using spare drivers when justified) or regulatory/security constraints which limit operating hours.

Under extreme conditions of inefficient operation with old vehicles on poor roads, utilization can be as low as 30,000 km per year, even on long hauls on main roads.

However, low utilization may arise for other reasons. For example, lower utilization is often found for trucks engaged in local deliveries, where hours of operation are restricted to suit customer needs, frequent loading/unloading takes place, and where urban traffic speeds are low.

In such cases vehicle utilization values in the range 40,000 - 80,000 km are not uncommon. Low utilization figures may also arise because of large seasonal variations and the need to meet peak demand or because particular customers value and are willing to pay for the additional reliability and flexibility derived from having excess transport capacity. In such cases low utilization and high costs are not indicators of inefficiency.

Vehicle utilization depends partly on the vehicle availability (or proportion of days when it is available for work rather than under repair), time spent loading/unloading, resting or looking for work, and on average haulage speed. Through efficient fleet management the proportion of fleet out of action due to repairs and maintenance should be less than 15%. Rest days can also amount to 15% of possible working days, while only half of working days may involve actual haulage rather than loading/unloading or running empty. An average haulage speed (including rests) of 50 km per hour is achievable on good roads with adequate truck power/weight ratio (say 7 - 10 Horsepower per Gross Vehicle Weight). Average haulage speeds (including rests) of only 20 km per hour were attained in Pakistan because of low power-to-weight ratios (only 5 - 7 in some cases because of overloading).

The freight-carrying performance of trucks (tonne-km carried per year) depends not only on vehicle utilization but also on average loads. Average loads vary substantially in accordance with the demand pattern (which affects the probability of return loads) and the degree of overloading, which is very common in developing countries. In Pakistan the average load factor is about 100%, with only about 10% of empty running balanced by the estimated 10% average overloading. Elsewhere it is not uncommon to find average load factors of about 60-70%, with figures as low as 50% the norm for specialized trucks such as oil tankers.

Assessing level of service is less easy than assessing costs and often has to be based on the views expressed by customers about the general scope of trucking services and their reliability. If the customers can supply the information, use can be made of indicators such as

- delay from when transport is requested or when it is expected to arrive, to when the truck actually arrives to load (usually less than 2 - 3 hours or so),
- delay from when transport is expected to be delivered, to when the truck actually arrives to unload (can be more than one day on long hauls),
- build-up of inventories in warehouses due to insufficient transport,
- time taken to unload consignments (1 - 8 hours depending on nature of goods and handing methods),
- amount of damage and losses incurred in road transport (compared to what is considered acceptable by the customer).

2.3 Analysis of Problems that Affect Trucking Performance

The types of problem that commonly affect performance are indicated in the table below. Note that problems arising specifically from regulating road transport are described in more detail in Assessing Regulation in Road Transport.

It is difficult, if not impossible, to do much about some of the problems listed in the table - for example, the seasonal variations in demand. However, it is helpful to have a knowledge of the wide range of factors that can adversely affect performance in order

1. to provide a sound basis for focusing on those areas where policy or regulatory change may be most beneficial, and
2. to understand the constraints on possible change and, more importantly, the realistic scope for improvement.

Even in the case of the demand pattern, there may be scope for policy action because, for example, demand for agricultural crop transport may be strongly affected by government agricultural marketing policies.

Problem	Comments
Demand	
Seasonal variations	Reduces overall equipment and staff utilization because these resources are under-utilized outside peak periods
Equipment	
Old designs	Many countries have large numbers of vehicles with obsolete designs, with high operating costs, possibly unsuitable for modern needs
Poor condition of vehicles	Lack of maintenance staff trained in modern technology, poor management (common in state-owned enterprises), ineffective roadworthiness regulations/enforcement
Expensive vehicles	Possibly attributable to uncompetitive local vehicle dealerships (possibly state-owned or with unviable distribution networks established under vehicle delivery aid programs), high import duties
Expensive supplies	Possibly attributable to uncompetitive local vehicle dealerships and spare parts/tire manufacturing outfits (possibly state-owned), a wide variety of vehicle types possibly related to deliveries of particular models chosen by aid agencies rather than those chosen by the operators, high import duties and cumbersome import procedures
Operations	
Loading practices	Overloading is common in developing countries, allowing higher freight-carrying performance despite slower speeds and higher road provision costs
Excessive driving speeds	Poor training/control of drivers can increase operating costs and accidents, also related to weak enforcement of traffic rules
Driver fatigue/drug abuse	Poor training/control of drivers can result in excessive driving hours, also related to lack of effective driver hour regulations and lack of secure parking
Lack of less-than-truck-load or other value-added services offered by truck operators	Usually only simple types of trucking service can be found in developing countries, avoiding the need for even basic documentation and support systems
Excessive delays at borders	Usually related to inefficient customs and other border controls
Poorly developed logistics services	Related to lack of development of modern, efficient distribution systems, to poor communications systems and to lack of trained transport management
Environment (Physical and Institutional)	
Road standard and condition	Usually a major factor determining costs and speed (partly dependent on speed limits and their enforcement)
Inadequate road signs and traffic measures	Attributable to lack of effective road safety programs
Traffic conditions and congestion	Can be a significant problem in densely populated areas, especially if roads are used by slow moving vehicles and road-side dwellers for non-transport purposes
Terrain	Mountainous terrain increases vehicle operating costs and reduces speeds
Crime	Road transport operators are vulnerable to hijacking and theft in many countries
Corruption and arbitrary enforcement	A frequent complaint from operators is about the bribes they have to pay to enforcement officers, often related to unclear

	regulations
High cost of credit	Road transport business is usually regarded as high risk, partly due to inadequately trained management. Can lead to short-term operating practices that shorten the life of equipment
Weak formal technical support industry	Can limit the quality of maintenance services and can be related to complicated business regulations which discourage formal workshop businesses and encourage provision of informal 'roadside' maintenance services
Lack of freight forwarding or brokerage industry to market freight services and arrange back-loads	Limits efficiency and role played by small operators, can be related to unattractive tax regulations which discourage agency businesses
Lack of competitive insurance industry	Many countries have poorly developed industries which charge excessive premiums, yet are unable to meet claims
Inadequate taxation system for road transport	Due to difficulties in assessing tax liabilities of small operators, tax assessments can be arbitrary and unpredictable, and do not encourage investment by giving tax allowances for capital investments
Other aspects of the general business environment	Labor laws, land ownership laws and business licensing procedures can be burdensome on road transport businesses and constrain innovation and investment

Other indicators can be used to assess the general conditions of the trucking industry and any important factors that affect costs and level of service. In particular the following four aspects may be relevant.

Firstly, the average ratio of trucks per operator indicates the ownership structure of the industry. This ratio is typically between about four and ten in Europe, whereas before deregulation in the 1970's it was only 1.5 in Chile because of the fragmented nature of the industry and absence of trucking companies in that country. This ratio varies between the common-carrier and own-account sectors (the latter tending to have smaller fleet sizes and smaller vehicles).

By contrast the lack of small operators is shown by very high numbers of trucks per operator in the CIS before economic reforms began in the 1990's (180-420 trucks per operator). (See Jenkins I. A. “All change - new directions for the road transport industries of Russia, Ukraine, Kazakhstan and Belarus”. Transport Reviews, Vol. 14, No. 4, 289-320, 1994). More information on this publication may be found at the Taylor & Francis Publishers Web site.at http://www.tandf.co.uk/journals/frameloader.html?http://www.tandf.co.uk/journals/tf/01441647.html. Some Eastern European operators had even higher ratios (between 130 and 570). Even in Mexico, before deregulation, this ratio was 53, reflecting the strong influence of a small number of large operators.

The proportion of traffic carried by own-account trucking can also indicate important characteristics of the transport industry and the way it might be regulated. In Europe, to avoid restrictions imposed on truck licensing, the proportion of own-account trucking (in terms of total road tonne-km) was increasing steadily up to 40% before deregulation was introduced. This figure was as high as 70% in the CIS before economic reforms occurred, compared to only 30% in liberalized countries.

A lack of specialization in trucking may also indicate poorly developed transport businesses and inefficient/poor services (as found in Chile before deregulation). Poor logistics systems are another warning sign (for example in Mexico, services before deregulation were so bad that, according to unconfirmed reports, whole industrial production lines had to be closed sometimes because of unreliable transport). In many developing countries there is a lack of even basic less-than-truck-load service.

When comparing the characteristics of road transport in countries where population density is low and haul distances long and conversely where population density is high and haul distances short, it would be expected that in the high-density country

- there will probably be less concern to obtain back-hauls for the shorter return distances,
- for the same reason, own-account trucks will have a larger share of the market, and
- small trucks will make up a large share of the market (not only because of the shorter hauls but also because they can get easier access along narrow streets to city premises, especially for the small frequent consignments required by small businesses).

3. Factors Affecting Bus Performance

As indicated above, passenger fares vary with distance, vehicle size and quality of service, road conditions, demand pattern, extent of regulation and extent of competition.

The influence of these various factors can be assessed through examining the cost breakdown of bus services, measuring performance indicators and detailed analysis of transport problems, as described below.

Care should be taken when inferring costs from the fares charged by state enterprises because of the possibility of fares subsidy. Furthermore cross-subsidies among routes are also quite common in regulated economies, which make comparisons of costs among routes very difficult.

3.1 Cost Breakdown

The typical breakdown of bus operating costs in a low- or medium-wage economy is shown in the table below.

Cost Item	Proportion of Operating Cost (%)
Variable Costs	
Fuel	20 - 30
Lubricating Oil	1 - 5
Tires	5 – 10
Spares	5 - 10
Fixed Costs	
Driver and other platform staff	10 - 15
Other Labor	about 5
Depreciation and Interest	20 - 30
Overheads and other costs	5 - 15
TOTAL	100

The cost breakdown varies between types of operation. In the case of informal small-scale operation using rehabilitated or locally fabricated buses, financed by overseas remittances, depreciation and interest costs are much less (only about 10% of total costs), while driver and other staff costs can be relatively more (20 - 30% or so), due to the higher number of people employed per unit of capacity (often including the owner).

The fuel consumption of a large bus with 60 seats operating long distances in flat terrain is typically 30 - 45 liters per 100 km (40 - 60 for air-conditioned buses). Minibuses with 20 seats can achieve consumption rates of only about 10 - 20 litres per 100 km. The number of staff employed per bus is usually two or three depending on rostering practices (if two drivers are assigned to one bus and if a conductor is employed).

3.2 Measuring Performance

Bus utilization (bus-km per year) strongly affects the balance between fixed and variable costs and gives an important indication of overall efficiency. A higher-than-expected proportion of fixed costs may indicate that utilization is much less than the 100,000 - 150,000 km per bus which is a potential range for long-distance operations. Lower utilization figures could result from inefficiency due to

- poor roads which may limit speeds,
- unreliable buses which break down often,
- lack of efficient scheduling using more than one driver when justified.

Utilization of 30,000 - 60,000 km per bus per year is often observed, although this may not be attributable solely to inefficient operations. In many situations, especially over short distances, to and from market centers, the passenger demand pattern is very uneven - for example, characterized by major flows in certain directions at one time of day, followed by little traffic until later in the day. Day-to-day and seasonal variations also can be substantial. Low utilization in these situations arises from the need to serve peak demand, and is not an indication of inefficiency.

Vehicle utilization depends partly on the bus availability (or proportion of days when it is available for work rather than under repair), amount of idle time when there is low passenger

demand or when operations are curtailed (perhaps for regulatory or security reasons), and on average journey speed. Through efficient fleet management the proportion of fleet out of action due to repairs and maintenance should be less than 15%. Long-distance routes on good roads should permit daily utilization of 400 - 500 km, equivalent to 8 operating hours at 50 - 60 km per hour. For local services with uneven demand, utilization may be limited to only 150 - 250 km per hour (implying that the bus is active for less than half of the day, assuming an average speed of 50 km per hour).

Utilization depends on the scheduling technique: if the bus operates a timetabled service it is likely to achieve a higher distance operated than if it is dispatched only when full after waiting in a queue of other buses. The latter form of operation is very common in developing countries and can lead to very low utilization, although average loads can be higher (nearly 100% in many cases compared to about 60 - 70% for many timetabled services).

Level of service of bus services can be assessed from quantitative measures such as:

- passenger travel times, including walking and waiting time,
- predictability of departure and arrival times,
- the rate of bus breakdowns (typically about 0.1 per thousand km, resulting in less than about 0.1% of scheduled distance not operated)
- availability of special features such as comfortable chairs, air conditioning, toilets, videos/music, and
- passenger facilities at bus stations.

In addition there are qualitative aspects of level of service which are difficult to quantify or to assess in importance, from the passenger's point of view, such as cleanliness and availability of timetable information. These aspects can be assessed using survey techniques designed to reveal how passengers make choices, or rank in importance one aspect of service from another.

3.3 Analysis of Problems that Affect Bus Performance

Many problems that affect bus performance are listed in the table of problems affecting trucking presented earlier. Additional problems specific to bus services are listed below (note that this excludes problems that arise from the regulatory system, which are described in more detail in another annex). Analysis of such problems can reveal how measures can be taken to increase performance.

Problem	Comments
Demand	
Travel patterns	Often severely limit utilization of buses to certain times of day
Operations	
Lack of timetabled bus services	Many groups of small operators dispatch buses from terminals only when full, which makes service times uncertain to passengers and limits utilization of buses
Lack of passenger choice over type of service and operators	In some countries passengers get little choice of service type (standard or deluxe seating), frequent small buses or less frequent large buses, services using new or old buses
Lack of private sector bus operators on route services	Could indicate undesirable state intervention or at least the threat of it

4. Measuring Performance

When trying to assess performance of road transport the challenge is to find reliable ways to measure the costs and level of service indicators described above. Two approaches are possible - using existing information or carrying out surveys.

The problem with using existing information in developing countries is that the data available to measure performance are unreliable. In many countries the number of vehicles is not known accurately because records may include vehicles which are no longer active or do not include data from remote regions. Errors in recording vehicle characteristics, sometimes deliberately made in order to avoid paying correct vehicle registration charges, and poor database systems, often make it difficult to measure important characteristics such as carrying capacity of the vehicle fleet and its age distribution.

Estimating vehicle utilization from national statistics is even more problematic. No reliable data can usually be obtained from the owners of road vehicles (especially small commercial operators in the informal sector). Instead estimates are made based on road-side traffic counts and interviews. However these generally only cover parts of the main national road network and exclude secondary and rural roads. More seriously they exclude urban traffic.

To minimize the need for the alternative approach of carrying out special surveys, which would obviously involve additional expense, consideration should be given to using existing data to estimate important road transport performance characteristics in at least two different ways and cross-checking the results. For example, vehicle output can be estimated by (a) estimating the product of number of vehicles and the estimated utilization in vehicle-km (or tonne/passenger-km), and (b) estimating vehicle-km (or tonne/passenger- km) from the length of road network and its average traffic flow and loads. Vehicle resources expended per unit of output of transport services can be estimated by (a) estimating vehicle operating costs for each component (fuel, oil, tires, staff, depreciation etc.), and (b) average charges paid by customers for services (per tonne/passenger-km). In this context, a knowledge of total fuel consumed in transport is useful to know, although this is far from easy to determine, because fuel consumption statistics often do not distinguish fuel used in transport, agriculture and industry.

For development of policy the government needs to monitor demand and supply conditions in road transport. Suggestions are given in the annex on Road Transport Administration for the minimum information required to assemble and keep up-to-date a suitable monitoring database. This database can be used not only for routine follow-up of key indicators but also for sampling additional data which may be required from time to time to investigate specific issues.

Where surveys are essential, the following types of survey can be considered.

1. **Roadside counts and interviews**, which are able to be adapted to give comprehensive information on characteristics of supply and demand. Regular (or even continuous automatic) counts over selected points of the network can give an estimate of total road traffic, its composition into main vehicle types, and trends in its development. Interviews carried out for limited periods (say twice a year) for a sample of vehicles can collect information about demand (commodities carried, origin and destination) and about supply (vehicle characteristics, vehicle ownership etc.). Such data do not represent all road traffic because the survey has to be restricted to main roads in order to minimize costs: it therefore does not reveal information about traffic on local roads or roads in urban areas. In order to keep the interviews short, to minimize road user inconvenience, information has to be limited to a few brief factual items. When limited in this way, roadside counts and interviews are an affordable means of collecting data needed not only to assess road transport characteristics, but also to plan development of infrastructure.
2. **Interviews of hauliers, consignors and freight forwarders**. The main purpose of such interviews is to find out customer level of service and charges. This can be done simply through an unstructured interview in which the aim is to discover the main concerns and issues affecting customers, or a more structured questionnaire can be developed in order to assess the importance of each aspect of level of service. In either case specific data on typical charges and transport characteristics can be obtained. Such interviews are expensive to carry out and usually they are only carried out for occasional studies, often to check more extensive data collection through other means. Care has to be taken to check information from such sources in case it is inaccurate or not representative of road transport as a whole.
3. **Analysis of operating records**. Usually such data are only available in the formal commercial sector, although in some countries drivers keep diaries of operations and expenditure. This can give, at one extreme, just basic operating statistics such as vehicle-kms operated and fuel consumed. At the other extreme it can give detailed published accounts showing revenue and expenditure, together with supporting transport statistics for an individual operator. This type of data could in principle give much useful information about the supply of road transport, especially if the operators are selected carefully so that they represent road transport as a whole. However, operating records are often inaccurate, partly because tax liabilities are assessed using them. Therefore great care has to be taken when interpreting the information, especially on costs and revenue. Cross-checking the information (for example vehicle-kms with fuel consumed and revenue earned) is helpful, but even this does not guarantee accurate results. Nevertheless this type of survey can give potentially useful data at relatively low cost.
4. **Interviews of informal drivers/operators in operational centers**. This type of survey is mainly useful for identifying potentially important issues and concerns of transport operators and for cross-checking data obtained from other sources. It can rarely give reliable data but can reveal operating practices and main problems seen from the operator's point of view. If a structured questionnaire is developed it may be possible to determine more precise information

about operating characteristics, but it is usually necessary to cross-check the results with data from other sources to confirm its authenticity. This type of survey is usually only carried out on an occasional basis, to monitor views in the informal operator sector.

5. **Analysis of past records of transport data**. This is an inexpensive way of analysing changes in the industry and is useful to identify traffic trends and possible effects of past regulatory changes. Such information can be used to estimate, from time series data, elasticities of demand and other economic variables. It can also be used as a basis for forecasting, providing past trends are a reasonable indication of future development.

Establishing causal relations between factors that affect performance is difficult, because so many factors may be at work. Hypotheses can be tested through with/without or before/after comparisons of performance, preferably using statistical tests such as regression analysis or analysis of variance. In most cases it is prudent to cross check the results with information from other sources. An example of an analysis of trucking in Korea is described in Smith G., Mitchell T, and Shin B. "Assessing the Effects of Trucking Regulation in Korea". World Bank Transportation Department, May 1986.

Another example of how a variety of surveys can be used to analyse the road freight industry is described in the report Hine J. L. and Chilver A. S. "Pakistan road freight industry: An overview". TRL Research Report 314. TRL. Crowthorne UK. 1991. More information on this publication may be found at the TRL Web site at: http://www.trl.co.uk/