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. Funding was provided from the Transport and Rural Infrastructure Services Partnership (TRISP) between the Department of International Development (DFID) of the Government of the United Kingdom and the World Bank.

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

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LOW VOLUME RURAL ROADS

(Based on World Bank Technical Paper 496, 2001, Prepared by Jerry Lebo and Dieter Schelling [*i*])

The objective of this note is to advise on an appropriate economic appraisal methodology that should be used for the assessment of Low Volume Rural Roads – that is roads upon which less than 200 motorised vehicles per day travel. The primary objective of such roads is the provision of *basic access*[1], which is the minimum level of infrastructure required to sustain socio-economic activity. Accordingly the provision of basic access is often viewed as a basic human right similar to the provision of basic health and basic education.

Various studies have provided evidence that poverty is also more pervasive in “unconnected” areas that is areas with no or unreliable (motorised) access. For example, in Nepal, where the percentage of people below the poverty line is as high as 42 percent, the incidence of poverty in unconnected areas is 70 percent; in Bhutan, the enrolment of girls in primary schools is three times as high in connected villages compared to unconnected ones and in Andhra Pradesh, India, the female literacy rate is 60 percent higher in villages with all-season road access compared to those with unreliable access.

Section 1 of this note sets out the reasons that Low Volume Rural Roads require a slightly different consideration from other transport projects. Section 2 discusses the approaches to economic evaluation that can be used for low volume rural roads, whilst Section 3 presents the manner that the consumer surplus method can be extended to account for the characteristics of low volume rural roads. Section 4 contains a summary of the main points of the note.

[1] Basic access is one of the necessary conditions for the alleviation of poverty in rural areas of developing countries, at a par with the provision of other "merit goods" such as basic health and basic education services. Basic access is defined as: the availability of all-weather road access from villages to the main road network; and reliable access to basic social and economic services on the intra-village track and path network (on which trips are made mainly on foot or by non-motorised means of transport). In cases of rugged terrain, low affordability, and low provision of motorised transport services basic access might mean all-season access only by non-motorised means of transport.

CHARACTERISTICS OF LOW VOLUME RURAL ROADS

The main characteristics of low volume rural roads that set them apart from more conventional highways are:

- The development of the road has a high potential to influence economic development through supply side effects. For example improved accessibility may lead to changes in crop types - from subsistence crops to cash crops - or to improvements in health and education leading to more productive days work per year and a better skilled workforce;
- The majority of the road users will travel using a slow mode, that is the majority of the traffic will consist of pedestrians and Non-Motorised Traffic;
- Foot traffic (pedestrians and animals), NMTs and motorised vehicles tend to intermingle in the traffic stream. Consequentially, accidents tend to be dominated by single vehicle type accidents and accidents between motorised and non-motorised traffic; and
- There will generally be periods during a year with disrupted passability.

Improvements in rural access typically give rise to benefits that arise from four sources:

- Lower transport costs to existing traffic due to smoother and sometimes shorter routes;
- Savings in time due to faster travel;
- Economic development benefits resulting in generated (new) traffic; and
- Social benefits due to improved access to schools, hospitals, etc.

The first of these is the most important in conventional highway appraisal in developing countries. Whilst lowering transport costs is still relevant to the appraisal of improvements to rural access, the other sources of benefit are proportionately more important. Thus, whereas conventional appraisal of investments in highways can focus exclusively on the benefits due to lower transport costs, this is not appropriate for rural access appraisal (DFID, 2002 [ii]).

APPROACHES TO THE ECONOMIC EVALUATION OF LOW VOLUME RURAL ROADS

The *Framework* sets out the overarching cost benefit analysis approach for the economic evaluation of transport investments. This is a consumer surplus based approach. Two other approaches exist and can be applicable to low volume rural roads. The first is the producer surplus approach, whereby changes in the profitability of the local agricultural producers are considered as an estimate of the benefit of the road investment and the second is cost effectiveness.

Consumer Surplus Methods

Consumer surplus methods are well established and have been applied in road investment models, such as the Highway Development and Management Model, Version 4 (HDM4). The methods are reliable to apply to higher-volume roads (greater than 200 vehicles per day (VPD)). However, its application to low-volume roads encounter problems related to the small magnitude of user benefits and the stronger influence of the environment rather than traffic on infrastructure deterioration.

For traffic levels between 50 and 200 VPD, and particularly for unpaved roads, a modified and customised approach can be taken, as in the recently developed Roads Economic Decision Model (RED). RED simplifies the economic evaluation process but at the same time addresses the following concerns related to low-volume roads: (a) reduces the input requirements; (b) takes into account the higher uncertainty related to the inputs; (c) allows for the incorporation of or modelling of induced traffic (based on a defined price elasticity of demand); (d) quantifies the economic costs associated with the days-per-year when the passage of vehicles is further disrupted by a highly deteriorated road condition; (e) optionally, uses vehicle speeds as a surrogate parameter to road roughness to define the level of service of low-volume roads; (f) includes road safety benefits; (g) includes in the analysis other benefits (or costs) such as those related to non-motorised traffic, social service delivery, and environmental impacts, if they are computed separately; and (h) presents the results with the capacity for sensitivity, switching values and stochastic risk analyses. The model is implemented in a series of Excel workbooks that estimate vehicle operating costs and speeds, perform economic comparisons of investment and maintenance options, switching values and stochastic risk analysis. RED can be downloaded from http://www.worldbank.org/html/fpd/transport/roads/tools.htm An example of the application of the RED model is shown in Box 1.

For traffic levels below 50 VPD, as is the case on the majority of Rural Transport Infrastructure (RTI), the consumer surplus approach needs to be augmented as the main benefits do not arise from savings in motor vehicle operating costs, but instead relate to the provision of access itself. The benefits of access are difficult to quantify. Also, traffic on such very low volume rural transport infrastructure (RTI) typically consists of a majority of non-motorised vehicles (where part of the costs are human energy needed to pull or push the vehicles, which cannot be easily priced), animal transport such as haulage by mules, walking and head loading (porterage).

Box 1. Roads Economic Decision Model (RED)

Surfacing a Gravel Road: A two-lane gravel road, with 200 vehicles per day, receives maintenance that consists of grading every 90 days and regravelling every 5 years, which yields a road with good passability and average roughness equal to 11.0 IRI. RED is used to evaluate the following project-options: (a) rehabilitate the road and improve the maintenance policy increasing the grading frequency to one grading every 60 days, (b) upgrade the road to surface treatment standard, and (c) surface the road with concrete blocks. The basic inputs are given in the Table below.

	Without project Grading every 90 days			
Average roughness (IRI)				
Investment cos ($/km)t				
Maintenance cost ($km/year)				

Option 1 investment cost is the regravelling cost and options 2 and 3 investment costs are the paving costs, considering a 6.5 m wide surface treatment road and a 4.0 m wide concrete block road. The future maintenance costs needed to maintain the defined levels of service are estimated for each case. The analysis period is 10 years, discount rate is 12 percent and economic to financial costs multiplier is 0.85. The price elasticity of demand for transport is set to 1.0 for all vehicles, meaning that a one percent decrease in transport costs yields a one percent increase in generated traffic due to reduction in transport costs. The results, given in Table F.2 below, show that options 1 and 3 are economically justified with a rate of return greater than 12.0 percent, while option 2 (upgrade the road to a surface treatment standard) is not justified, at the given discount rate of 12 percent, mainly to the relatively low traffic and high investment costs.

Rehabilitating the gravel road has positive economic benefits, but this option is fairly responsive to changes in the future maintenance policy, and the corresponding maintenance costs. Therefore, there should be some assurance that the road agency has the capacity to maintain the road before the rehabilitation is implemented. The option of surfacing the road with concrete blocks has the highest rate of return (33 percent) and under the sensitivity scenarios it maintains a high rate of return. Therefore, it is an economically robust option. This evaluation considers a 4.0 meter-wide concrete block road, but if one considers a 6.5 meter-wide concrete block road, at a cost of 78,000 $/km, the rate of return drops to 14 percent. A switching values analysis indicates that the daily traffic should be 180 vehicles per day to marginally justify a 6.5 meter wide concrete block road and 90 vehicles per day to marginally justify a 4.0 meter-wide concrete block road. Note that these results are for a particular set of road user costs, traffic growth rates and condition of the road under the without project case. Therefore, the results can not be generalized.

Source: Archondo-Callao 1999[iii]

Producer Surplus Methods

Producer surplus methods are discussed in detail in Carnemark, 1976 [iv] and Beenhakker, 1983 [v]. The method requires assumptions concerning the impact of transport investments on local agricultural productivity and output which are difficult to assess, particularly in a situation where interventions are expected to open up new areas and adequate production data may be difficult to compile (see also the World Bank's Handbook on Investment Operations, World Bank (1998) [vi]).

In cases where no road exists and a significant change in vehicle accessibility is planned, the producer surplus method can appear to be the most appropriate procedure. However, the following problems and limitations need to be taken into account:

- The method only considers agricultural freight, which often accounts for less than 20% of rural road traffic. Passenger benefits and other non-agricultural benefits still need to be calculated separately;
- The method requires a detailed knowledge of agriculture and its likely response to changes in input and output prices;
- The data requirements for this method are usually very large;
- The experience of the practical application of the method has been poor. The empirical justification for estimating changes in agricultural production has been weak and a failure to consider all the relevant costs of production has often led to benefits being grossly overvalued.

To the extent that low volume rural road investments are increasingly focused on social rather than economic objectives, the application and relevance of the producer surplus method has decreased in recent years. Generally this method should only be used in special situations where the required knowledge and data is available or can be collected at reasonable cost.

Cost Effectiveness Analysis

Consumer surplus methods rely on the ability to be able to measure costs and benefits in monetary terms (*see TRN 5: Framework*), which renders them problematic for projects where a significant component or the majority of benefits cannot be readily monetised (e.g. a Low Volume Rural Road). In such situations consideration should be given to the use of measures derived from cost effectiveness or weighted cost effectiveness (also known as Multi Criteria Analysis) techniques as the basis for the decision regarding whether to invest or not.

Cost effectiveness techniques are also a very useful tool for project screening or ranking. Such a screening process ensures that projects that are subjected to a more detailed analysis (including cost benefit analysis) are those that best fit with the objectives of the investment (e.g. poverty alleviation).

TRN 6: Where to Use Cost Effectiveness techniques rather than Cost Benefit Analysis provides a detailed description of the methodology to be adopted, the situations in which cost effectiveness is applicable and some case study examples.

EXTENDING THE CONSUMER SURPLUS APPROACH FOR LOW VOLUME RURAL ROADS PARTICULARLY THOSE WITH LESS THAN 50 MOTORISED VEHICLES PER DAY

As discussed above, conventional consumer surplus approaches to cost benefit analysis do not account for many of the benefits of rural transport infrastructure investments. Extending the approach therefore holds promise for improved analysis. The proposed enhancements are aimed at finding broader measures of economic benefits and costs applicable to low volume rural roads. Such an analysis may well require a multi-sectoral "team" approach that involves not only transport analysts but may also include specialists from the fields of agrarian, health, education, water and say electricity supply. Thus, while the principles of analysis are the same, the special features of low volume rural roads call for special methods of analysis. Possible enhancements include:

- Better assessment of the costs of interrupted access;
- Estimating operating cost savings of NMT;

- Savings due to mode changes (from NMT to motorised transport);
- Improved valuation of time savings; and
- Valuation of social benefits from improved access to schools and health centres.

Better Assessment of the Cost of Interrupted Access

For cases where passability suffers during the rainy season, an assessment can be made of the extent of interruption. Seasonal changes in transport quality can be assessed on the basis of local socio-economic impact, such as higher goods prices, lost productivity, or decreased social travel. In such cases, an assessment of the impact on particular activities may be necessary, since losses associated with seasonal interruptions will vary by activity (agriculture, marketing, travel for jobs and related wage earnings, school attendance and consequent decline in quality of education, health visits, etc). It may be difficult to directly observe the impact of seasonal access variations, and such information will usually need to be collected either through a local survey or other participatory processes.

In addition, it may be possible to examine the costs associated with alternative (but longer) routes (that increase transport cost and time), or substitutes for transport (migration, storage), or even lost opportunities and income, to better understand the impact.

Estimating Operating Costs Savings of Non-Motorised Transport (NMT)

Methods for calculating the non-motorised transport (NMT) user cost savings from road improvements have only recently become a part of project evaluation. Studies in Bangladesh and Indonesia have estimated user costs for a set of NMT and the results of these studies have been integrated in the HDM4 model (Padeco, 1996 [vii]) and (World Bank, 1996 [viii]). In particular circumstances, additional country- or area-specific fieldwork may be necessary to get realistic estimates of NMT costs. Particular information is required regarding operating costs in relation to differing road surface conditions. *TRN 22: Treatment of Pedestrian and Non-Motorised Traffic* details the approach that should be adopted.

Savings due to Mode Changes (from NMT to motorised transport)

Very significant savings can be made due to road improvement- or construction-induced changes in the modes of transport. Resulting costs can be 5-10% of those that were previously incurred, as shown by the case study in Box 2. The reader is again referred to *TRN 22*: *Treatment of Pedestrian and Non-Motorised Traffic*.

Box 2. Savings due to Mode Changes in Ghana and Elsewhere

Studies in Ghana (and elsewhere) have established that head porterage takes about two person-days to move one ton-km, using factors of average load size, walking speed per hour, and time for the return trip (without load). Using the minimum wage rate, this amounted to about US$2 to 2.50 per ton–km. The minimum wage is taken as a proxy for the resource costs (food, expenses, etc.), and for the time and effort involved.

More recent studies indicate that where transport is not available, the rural poor experience a shortage of productive time in doing various chores in their daily lives and farming, marketing, and transport activities, and therefore their time should be given a higher monetary value. This is indeed a valid consideration, but not reflected in the price noted above. The estimated rate of US$2 to 2.50 per ton-km mentioned above was also found to reflect the actual market charges for such operations.

This rate range is found valid for head porterage in many developing countries. In Balochistan (Pakistan), Nepal, and Bhutan, where mule transport is a common form of transport in rural areas, the actual cost is found to be about US$3 to 4 per ton-km, including the cost of the mules and the persons walking with them. In Bhutan, a similar rate was found through market inquiries of actual charges levied, and also from indicative tariff rates published by the Royal Government of Bhutan. This rate should be compared with about US$0.20 per ton-km for trucking operating costs on low-volume roads, which would become applicable after road construction or improvement.

Source: Adapted from: Pankaj (1991) [ix]

Improved Valuation of Time Savings

A critical aspect of examining alternative RTI interventions is an understanding of the impact of improvements in infrastructure on journey times, and therefore (beyond the impact on vehicle operating costs) on productive time saved, including time associated with non-motorised travel and the transit time of freight. The process of valuing time in transport operations is not without controversy, and while there are currently no universally accepted methods for determining a "value of time," some general guidance is possible and is presented in the *TRN 15: Valuation of Time Savings*.

In addition to the conventional considerations that are required for the valuation of time savings, valuation of time savings on low volume rural roads should consider the manner that road users are disaggregated between work and non-work categories so as to accurately reflect the characteristics of the area which will typically be one where road users are: (a) predominantly self-employed; and (b) characteristically engage in multi-purpose, or simultaneous task trips (e.g. a trip to a regional centre may serve several functions both work (e.g. selling agricultural produce) and leisure (visiting relatives)).

Valuation of Social Benefits from Improved Access to Schools and Health Centres

It is often argued that the most important impacts of rural infrastructure improvements take place through changes in the patterns of personal mobility and increased social travel (Cook and Cook, 1996 [x]). Improved rural access provides social benefits in promoting education, particularly through increased enrolment of girls, health benefits, increased labour mobility, the spread of information and knowledge, and also improved access to markets. Many studies demonstrate the dynamic changes that improved rural mobility brings to the social and economic life of rural areas. A study in Bangladesh comparing two sets of villages showed that villages with road access, compared with villages without access, fared much better in farm-gate price of produce, fertilizer use, land under irrigation, household income, income per acre of field crops, wage income of landless labour, and percentage of employed women (Ahmed and Hosain, 1990 [xi]). Another comparative picture of villages from Bhutan, all under the same agro-climatic and cultural environment and also in the same district, not far from each other, showed male education enrolment rates 75% higher, female school enrolment three times as high and incomes over twice as high in villages that were less than half a days walk than in villages that were between one and three days walk from the nearest road.

In those circumstances it may be appropriate to make some estimate of the value of the social benefits of the improvement of basic access, as was attempted in the Bhutan Rural Access Project (see Box 3). A common approach to quantifying social benefits (particularly benefits from improved access to education and health facilities) is to use a sample case as guidance for assessing similar benefits from other roads improvements in similar areas or regions in the same country It is important, however, if this is being attempted, to take care to ensure that there is no **double counting** of benefits

Box 3. Assessing Social Benefit of Basic Access Improvement in Bhutan

The main objective of the Bhutan Rural Access Project was to improve the access of "stranded" rural communities to markets, schools, health centers and other social infrastructure. To do this it attempted to separately evaluate the social benefits, agricultural benefits and transport cost savings of one project road of 37 kilometers from Dakpai to Buli, as representative of other road links in the project.

A novel feature of the analysis was the quantification of part of the social benefits (in addition to transport cost savings) by estimating the value of better access to education which the road provided, using Bhutanese data on enrolment levels with improved road access and income levels of educated and uneducated people. Improved road access (removing the present constraint of about two days walking) will allow easy transport of children to schools or allow schools to be located closer to the communities. This will lead to higher school enrolment levels and improve the quality of the schools. RGOB had already planned on building new elementary and junior schools following road construction when travel times would be reduced.

Preliminary estimates based on higher enrolment rates in more accessible areas in the same district indicated that about 75-100 additional children would go to school if the road were built. More girls would attend and more boys would be released from the tasks of transporting goods. The life-time earnings of the educated versus uneducated samples provide an estimate of the income differentials. The net incremental income was assessed after deducting estimated education and continuing education costs. This was attributed as net value added by the road since the additional enrolment would not have occurred without it.

Some health benefits from better access to health centres, were also assessed based on reduced sick days away from work, lost net income, and other health savings (such as and reduced maternity and other deaths). Overall about 30 percent of the project benefits were estimated to derive from these quantified social benefits.

To ensure that the social benefits were not double counted within the estimate of the transport benefits; transport cost savings associated with agricultural, health and educational traffic were excluded from the total value of transport cost savings used in the economic assessment. The total volume of vehicles was, however, considered in the estimation of road capacity/saturation levels and the maintenance cost schedule.

Source: Project Appraisal Document on a proposed credit to Bhutan for a rural access project, World Bank, November 1999 [xii].

The Bhutan case also highlights other important approaches for the careful assessment of benefits from rural road access improvements. These benefits include the estimation of mule-haulage costs in the without-project situation, and the use of a 40-year life assumption for the road, which specifically is defined as a well-designed and erosion-protected mountain road with a gravel surface with expected good maintenance (in the case of Bhutan). Sensitivity analysis regarding these assumptions was done.

SUMMARY

The provision of Rural Transport Infrastructure (RTI), such as low volume rural roads, can have wide social and economic benefits. The improved accessibility arising through the investment can lead to a step change in several markets, such as agriculture, health and education, and the benefits of these changes will be felt in not just the economic sector but also in the social sector (e.g. gender issues).

A range of tools should therefore be considered when appraising a low volume rural road. This may well require a multi-sectoral approach to the appraisal, so as to incorporate the wider economic benefits. It should be noted that this requires substantial data assembly and collection. Should the analysis be extended to include benefits that accrue outside the transport market care should be taken to ensure that these benefits are not double counted.

The cost of appraising the wider economic benefits associated with a low volume rural road can be large relative compared to the capital cost of the investment due to the appraisal's technical complexity and data requirements. As such, cost effectiveness techniques can be appropriate (*see TRN 6: Where to Use Cost Effectiveness techniques rather than Cost Benefit Analysis*) particularly for the screening and ranking of projects. However, where cost effectiveness analysis is used as the basis for the decision regarding whether to invest or not, the economic viability of a sample project should be reviewed.

FURTHER READING

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