TRANSPORT NOTES

TRANSPORT ECONOMICS, POLICY AND POVERTY THEMATIC GROUP

THE WORLD BANK, WASHINGTON, DC Transport Note No. TRN-18 January 2005

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

Projects with a Very Long Life

Some transport investments, for example new Metro tunnels in cities, are expected to have a useful life of 100 years or more. Such a life far exceeds the standard appraisal period of 25 years (see *Framework*). In these cases, limiting the appraisal to a 25 year period can cause some discomfort to those responsible for promoting and funding the project. Are there not benefits beyond the 25 year horizon which ought to be taken into account?

In this note we address this issue by considering: what types of project typically have a very long life? (Section 1); the choice of appraisal period (Section 2); use of residual values (Section 3); pitfalls to avoid (Section 4); and the sensitivity of these matters to the discount rate (Section 5).

What Types of Project Typically Have a Very Long Life?

Some transport network assets have a very long engineering life. Earthworks and some structures – including tunnels, bridges and quays – are among the most important examples. As Table 1 shows, these can have useful lives of up to 100 years.

Some other network assets, which have an expected life shorter than this, are in absolute terms still very long-lived. For example, airport terminals, stations and other transport buildings can have expected useful lives of 30-60 years.

Table 1. Examples of Life Expectancies for Transport Assets (years)

<table>
<tr><th rowspan="2">Asset type</th><th colspan="4">Mode</th></tr>
<tr><th>Roads</th><th>Railways</th><th>Airports</th><th>Sea Ports</th></tr>
<tr><td>Earthworks/ drainage</td><td colspan="3">100</td><td>Up to 50</td></tr>
<tr><td>Pavement</td><td>20 to 25</td><td></td><td rowspan="2">10 to 15</td><td></td></tr>
<tr><td>Road surface</td><td>10</td><td></td><td></td></tr>
<tr><td>Track</td><td></td><td>14 to 40</td><td></td><td></td></tr>
<tr><td>Bridges/tunnels</td><td colspan="3">Up to 100</td><td></td></tr>
<tr><td>Signalling</td><td></td><td>10 to 50</td><td></td><td></td></tr>
<tr><td>Electrification</td><td></td><td>33</td><td></td><td></td></tr>
<tr><td>Telecomms</td><td></td><td>7 to 40</td><td></td><td></td></tr>
<tr><td>Buildings</td><td>50</td><td>30 to 40</td><td>Up to 60</td><td>Up to 50</td></tr>
<tr><td>Equipment</td><td>12</td><td></td><td>4 to 20</td><td>2 to 30</td></tr>
</table>

Note: data relates to asset lives in the UK.
Source: ITS. Based on the UNITE Transport Accounts for European countries, Link et al (2002)[i].

Note that the life of an asset usually varies with the maintenance regime. An intensive – and expensive – maintenance regime may be able to extend the useful lives of assets to the levels shown in Table 1, whilst a less intensive regime might reduce them below these levels. Asset life may also be vulnerable to environmental and climatic conditions, and to the specific types and levels of use to which the asset is put.

CHOOSING THE APPRAISAL PERIOD

In appraisal, the aim is to capture the full economic benefits of the project, and we would aim to do this, where possible, by appraising over the expected lifetime of the longest lived asset. So in the straightforward case of a bridge project, the starting point would be the engineering life of the bridge. This could be, for example, 80 years.

However, the appraisal period is also limited by the time period over which demand can confidently be foreseen. In other words, a project is expected to yield a stream of services that are useful to the population, and this stream of services is subject to uncertainty. In the longer term, the many sources of uncertainty include: potential economic instability; energy prices; shifts in land-use patterns; political risk; and supply side risks over the continued maintenance and operation of the asset itself. Given the vulnerability of projects to these risks, it is common practice even in politically- and economically- stable countries to curtail the appraisal period at around 25-40 years, even for a long-lived asset.

In practice, it is worth bearing in mind that at discount rate of 10%, benefits in year 41 would be worth only $1/50^{th}$ of benefits in year 0. Benefits in year 80 would be worth less than $1/1000^{th}$ of benefits in year 0. Therefore the implications for the NPV of curtailing the appraisal period are not usually significant (see Figure 1).

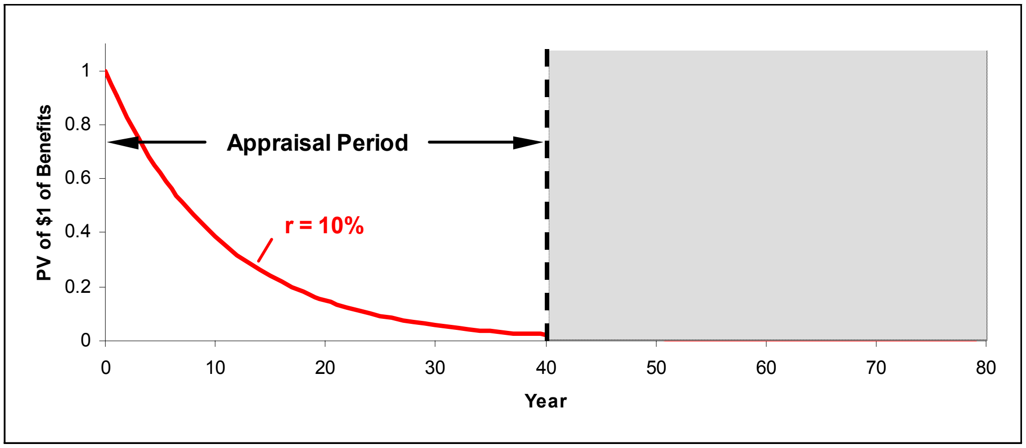

Figure 1. Effect of Discounting on Future Benefits

As indicated in *TRN 5: Framework,* typical transport projects will be appraised over a 25 year period. Only atypical transport projects with long lives will be appraised over a period greater than 25 years.

Use of Residual Values

Where a project is dominated by one long-lived asset – for example, the bridge described above – there may be some interest in knowing what the longer-term benefits are.

Residual value is an item in the appraisal which captures net benefits beyond the formal appraisal period.

A residual value is calculated in exactly the same way as the NPV, except that the time period is from (T+1) to ω, where ω is the final year of the project's life.

$$\text{Residual value, R} = \sum_{t=T+1}^{\varpi} \frac{B_t - C_t}{(1+r)^t}$$

The residual value is a net value. It includes the residual stream of benefits **minus** the residual stream of operating and maintenance costs.

In reporting the results of the appraisal, the residual value should be reported **separately** from the NPV and IRR. The form is: "Residual Value in Years xx to yy = $nnn". An example is given in Table 2.

Table 2. Appraisal Results and Residual Value for a Bridge Project

Years	Costs, $M Present Value @10%	Benefits, $M Present Value @10%			Net benefit, $M Present Value @10%
		Passengers	Freight	TOTAL	
0-3	200	0	0	0	-200
4-39	4	44	239	283	279
40-79	1	1	5	6	5

Net Present Value = $79M
over 40 years @10%

Internal Rate of Return = 14%
over 40 years

Adjusted Internal Rate of Return = 12%
over 40 years

Residual Value (i.e. net benefit in years 40-80) = $5M

Note that the key parameters in this example are: discount rate (10%), horizon year (80 years) and appraisal period (40 years).

SOME PITFALLS TO AVOID

Project Creates a Mixed Set of Assets

A major transport infrastructure project usually includes the creation of a mixed set of assets, including earthworks, structures, pavement (or track) and equipment. In these cases, a judgement will be required about the most appropriate appraisal period.

If the appraisal period is set long – for example, 40 years – then some of these assets will require **replacement** when they reach the end of their useful life, **during** the appraisal period. The replacement costs must be included in the stream of future costs in the appraisal, in the year when they will be incurred.

It will often be clearer for the decision-maker, and not necessarily detrimental to the NPV, to set the appraisal period to match the asset life of an asset with an intermediate life. For example, for a road project, suppose the pavement has a useful life of 20 years before renewal is required. In this case, it may be appropriate to evaluate over 20 years, rather than extend to 25 years, during which time expensive renewal work will be necessary.

Appraisal Period Is Not Flexible

Where the appraisal period has been determined in advance, for example by the administrator of a particular investment programme as a whole, residual values have a useful role to play. In these cases, the NPV and IRR must be calculated over the stated appraisal period. However, a residual value – calculated as shown above – can be calculated and reported in order to indicate what the consequences of the restricted appraisal period were.

SENSITIVITY TO THE DISCOUNT RATE

Finally, we must consider whether the choice of discount rate plays any role in the discussion of long-lived projects. Suppose that the rationale for the 12% discount rate used above is a shortage of capital, ie. it is a rationing device rather than a reflection of Social Time Preference (STP) and risk.

Suppose that the underlying STP rate is 5% but there is a strong need for capital rationing. Then, using the 12% rate rather than 5% will reduce the relative performance of long-lived assets.

In such conditions, it might be reasonable to test the sensitivity of certain projects to lower discount rates, with a shadow price on capital to represent capital rationing instead of an inflated discount rate.

General guidance regarding the choice of discount rate is given in the *Framework* and the issue is further discussed in the *TRN 6: When and How to Use NPV, IRR and Adjusted IRR* .

FURTHER READING

[i] Link et al (2001), Pilot Accounts- Results for Austria, Denmark, Spain, France, Ireland, Netherlands and UK, Deliverable 8, UNITE Project, Funded by EU 5th Framework RTD Programme. DIW: Berlin. [Available online at: http://www.its.leeds.ac.uk/projects/unite/]