Undertaking feasibility studies of railway projects and railway traffic costing

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PART 1: Feasibility studies of railway projects

Purpose - Why undertake a feasibility study?

• Determine whether, and under what conditions, a project will be technically, financially and economically viable

• Demonstrate to potential donors that project will produce acceptable commercial rate of return (i.e. it is both technically and financially viable)

• Demonstrate to governments and to other stakeholders that project will achieve acceptable social, or economic, rate of return
What is included in a feasibility study of a railway project?

- Demand analysis and traffic forecasts
- Engineering analysis and technical specs
- Capital cost estimation (land acquisition; civil works; signalling, electric power and control system installation; track-laying and initial rolling stock purchases)
- O&M cost estimation (train crew costs; fuel/energy consumption; loco/wagon/carriage maintenance; fixed infrastructure maintenance; variable infrastructure maintenance; station operating costs)
- Financial appraisal (revenue forecast; financing plan; DCF analysis, including calculation of FIRR and NPV indicators)
- Economic appraisal (benefit estimation: reduced operating costs, time savings, reduced emissions, accident cost reduction, reduced road maintenance costs; analysis of economic net benefit flows (benefits less costs), including calculation of EIRR and B/C indicators)
Feasibility studies are carried out for wide range of different types of railway projects.
List is not exhaustive, but indicates projects which have recently been studied/planned, or are currently underway in Asia.
Development costs range from nearly $100 million per route-km for construction of new urban mass transit railways to less than $500,000 per route-km for rehabilitation of existing mixed traffic railways.
Demand forecasts


- Many projects have failed to realize the benefits expected of them simply because demand has fallen short of forecast levels

- Since railway assets are long-lived (50 years or more), demand forecasts in terms of freight tonnage/tonne-km and/or passenger volume should cover at least 20 operating years beyond the construction period

- Extensive sensitivity testing of financial and economic results should be carried out for variation of demand from forecast levels

- If possible, risk analysis should be used to assess the downside risks of demand failing to meet forecast levels
## Engineering analysis

- **Basic** technical specifications (e.g. maximum or ruling gradient, minimum curvature, axle loading, loop lengths, station spacings, speeds and signalling requirements) should be established in advance of the Preliminary Design.

- These will provide basis for Capital Cost estimation.

## Capital cost estimates

- A works schedule should be established and capital cost estimates (at current unit values) prepared within this schedule.

- Capital cost estimates should cover: land acquisition; civil works; track-laying, signalling and power and control system installation; and initial rolling stock acquisition.

- Land acquisition costs will account for major proportion of project development cost in urban areas (especially in case of urban mass transit railways).

- Civil works will account for major share of development cost of projects involving extensive tunnelling and bridgework (around 50% in case of Chinese High Speed lines).

- Electric power and control systems, signalling and rolling stock can comprise up to 25% of High Speed development costs (e.g. case of Chinese 350 km/hour lines).
O&M cost estimates

• A reliable rail traffic costing model should be used to generate estimates of Operating and Maintenance costs which will be incurred for 20-30 years after start-up

• Relevant O&M costs include costs of:
  - train crews
  - fuel or electric energy consumption
  - locomotive and rolling stock maintenance
  - infrastructure maintenance (fixed and variable elements)
  - station and train control staff
Financial appraisal

• Will comprise a detailed Discounted Cash Flow (DCF) analysis

• DCF will determine the project’s financial viability under alternative assumptions with respect to: (a) revenue generation; (b) project capital and O&M costs; and (c) project financing arrangements

• Positive cash flows will mostly comprise revenue from collection of passenger fares, freight tariffs, or both – in case of High Speed and Urban Transit lines, additional revenue may be collected from retail concessionaires in stations

• Negative cash flows will comprise its capital, financing and Operating and Maintenance (O&M) costs

• Project will usually be financed by combination of different sources: Equity funds, long term foreign government or international agency loans, commercial loans, or in the case of high profile projects (like High Speed lines) from bond issues

• International development agencies provide loans with lowest interest and most generous pay-back terms, but (like Japanese ODA loans) usually specify a national income qualification

• Usually the case that FIRR’s of railway projects will fall below specified long term cost of capital owing to government imposed price controls, high cost structures, or competition from subsidized modes, e.g. road transport
Economic appraisal

• Appraisal involves estimation of the net benefits of the project to society through a comparison, over its life, of its economic benefits with its economic, or shadow-priced, capital and operating costs

• Shadow pricing involves the removal of taxes and government charges from costs, as well as compensation for price distortions (where prices not determined by market forces)

• Different types of railway projects will have different combinations of economic benefits (see following slide)

• High Speed Passenger Railway will offer substantial time savings compared with road and air (when all access costs are considered), whereas freight railway will not offer time savings but by diverting traffic from road will save road operating costs (as its major economic benefit)

• Railways will have some economic benefits which are not easily measurable, such as reduced exposure of local populations to noxious gas emissions and road traffic noise

• Except for High Speed Railways in populous countries, such as China, the savings in Greenhouse Gas emissions due to railways will not be great (small tonnages, valued at low rates)

• Well designed railway projects will usually achieve significant EIRR’s (in the range of 20-30%) – well in excess of the long term cost of capital
### Economic benefits from different types of railway projects

<table>
<thead>
<tr>
<th>Project Type</th>
<th>Relevant and measurable project benefits (economic appraisal)</th>
<th>Released capacity on existing rail network</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Value of Time savings</td>
<td>Reduced transport operating costs</td>
</tr>
<tr>
<td>New High Speed Passenger Railway</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>New Urban Mass Transit Railway</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>New mixed traffic railway (mainly freight)</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Track doubling/electrification</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Track rehabilitation/strengthening</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

* Likely to include reduced airport maintenance costs in case of High Speed railways

- New traffic generation and Value of Time Savings likely to be highest for High Speed and Urban Mass Transit railway
- Development of High Speed and Urban Mass Transit railway will also have greatest impact in terms of raising land values and of employment generation along railway routes
- Freight railways will offer highest reductions in road operating costs, road accident costs and road maintenance costs, owing to diversion of traffic away from heavy trucks on national highways
**Some impacts of High Speed Railway development in the Region**

*(World Bank Beijing Office, How China builds high-speed rail for less, 09 October 2014)*

- Dramatic pace of HSR development in China over past decade: 10,000 route-km built with further 12,000 route km under construction

- High density corridors, e.g. Beijing-Shanghai and Beijing-Guangzhou have 350 km/hour HSR’s, while 250 km/hour running design for lower density corridors

- Chinese 350 km/hour lines have unit development cost of US$ 17-21 million per km, as compared with US$ 25-39 million per km in Europe (and now significantly more in USA)

- While Chinese capital costs are one third lower than those of Europe, fares charged in China (US$ 0.077 per km for 350 km per hour services) are only 20-25% of typical fares charged for comparable European HSR services

- Likely that European services are self sustaining – therefore Chinese HSR’s with 67% of the cost and only 25% of the revenue are likely to be heavily subsidized by Government
<table>
<thead>
<tr>
<th>Economic appraisal of railway rehabilitation project, Cambodia</th>
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<tbody>
<tr>
<td>• Revised project involved rehabilitation of about 320 route km of badly degraded track (most on Southern Line between Phnom Penh and Sihanoukville Port) and construction of new rail container terminal within Sihanoukville Port</td>
</tr>
<tr>
<td>• Revised project cost US$ 142.6 million, mostly financed by ADB and AUSAID, completed mid 2015</td>
</tr>
<tr>
<td>• Initial economic appraisal undertaken in 2006</td>
</tr>
<tr>
<td>• Economic benefits expected to result from diversion of bulk and container traffic from heavy trucks operating along three national highways</td>
</tr>
<tr>
<td>• Benefits initially measured for project distributed as follows: Reduced road transport operating cost, 89%, reduced CO2 emission cost 3.0%, reduced road accident cost 3.0%, reduced road maintenance cost 5%</td>
</tr>
<tr>
<td>• Project estimated to achieve an EIRR of 21%</td>
</tr>
</tbody>
</table>
PART 2: Traffic costing for vertically integrated railways

- Version 2 of the “Traincost” model designed to assist costing of individual trains or OD traffic on vertically integrated railways

- Vertically integrated railways combine provision and maintenance of infrastructure with operations, unlike vertically separated railways and other modes of transport, where these functions performed by separate organizations

- In ESCAP region nearly all railways are vertically integrated (notable exception is Australia) - unlikely to change in foreseeable future

- Must be understood that traffic costing for a vertically integrated railway is a complex and difficult process *(high level of fixed costs, complex interactions between operations and infrastructure maintenance, operational constraints affecting costs, etc)*
Costing of point-to-point railway traffic – why is it needed?

- Desire to improve profitability of railways necessarily requires assessment of profit (or financial contribution) at a disaggregated level, i.e. at level of individual OD traffics or trains, routes and traffic segments

- Railway accounting systems do not provide disaggregated data for individual route or traffic analysis

- Neither are historical costs of railway accounting systems suitable for profitability analysis

- *Profitability of individual routes, trains and traffic segments must be assessed on basis of operational parameters which determine costs*

- Cost models which are activity or operationally based (such as “Traincost”) provide cost estimates for comparison with prevailing prices (freight tariffs or passenger fares)

- Resulting estimates of financial contribution for individual traffics or trains can be aggregated by route or traffic segment to establish route or traffic profitability

- Cost estimates can be re-assessed by varying operating parameters in order to improve route or traffic profitability
Common uses of railway traffic costs

- Cost inputs for assessment of individual traffic, route and traffic segment profitability, or financial contribution; thus can provide inputs for Corporate Strategy, Marketing and Operating Plans

- O&M cost inputs for feasibility or pre-feasibility studies of investment in railway infrastructure or operating assets (such as locomotives and rolling stock)

- Modal cost comparisons (e.g. comparisons of the economic costs of road and rail and road for given traffic types over a range of distances)

- Capital cost inputs for capital budgets (infrastructure and operating asset investment)
Railway cost structures and segmentation (1)

• Relatively high proportion of fixed costs (costs which do not vary with traffic volumes)

• Fixed % of total O&M costs about 80% for low traffic railways and 40-50% for high traffic railways

• Variable costs may be directly calculated for individual traffics and trains

• Fixed costs have to be allocated to individual trains or traffic – using an appropriate allocation basis

• “Traincost” allocates fixed costs in direct proportion to the number of trains operated per year e.g. if container trains comprise 20% of all trains operating on a line container traffic will be allocated 20% of fixed costs
Railway cost structures and segmentation (2)

Three cost classifications relevant for assessment of traffic profitability:

(i) **Short Run Marginal Cost** (SRMC) - addition to total costs resulting from addition of small increments, such as one more tonne of freight, to total output. *Includes only cost elements which vary in the short run (within 12 months), such as costs of train crews, energy or fuel consumption, locomotive and rolling stock maintenance, and variable track maintenance.*

(ii) **Long Run Marginal Cost** (LRMC), or SRMC plus other costs which vary only in the longer term (more than 12 months) but are directly attributable to traffic being costed. *Examples are capital costs of locomotives, wagons/carriages, and any infrastructure needed to support the costed traffic.*

(iii) **Fully Allocated** or **Fully Distributed Costs** – addition to LRMC of overhead or indirect costs which cannot be associated and do not vary directly with specific OD traffic. *Examples are head office overheads, provision and maintenance of signalling systems and fixed costs of infrastructure maintenance. Methods of allocation to specific trains often controversial.*
- Costs based on model run for intermodal traffic (Double stack container trains)
- Indirect costs represent about one third of total FD cost
## Model assumes trainloads maximized in line with railway operational constraints

<table>
<thead>
<tr>
<th>Constraint</th>
<th>Determines:</th>
<th>Has:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Operational Limits</td>
<td>Principal Cost Impacts</td>
</tr>
<tr>
<td>1 Max or ruling gradient on line (e.g. ( \geq 1.5%) )</td>
<td>Train trailing load (gross tonnes); Speeds (km/hour)</td>
<td>Rail re-profiling/replacement; Fuel consumption; Crew costs</td>
</tr>
<tr>
<td>2 Available traction power (e.g. 4,000 HP/2,940 KW per unit will allow high gross tonnage)</td>
<td>Train trailing load (gross tonnes)</td>
<td>Unit operating costs (train load increases, unit O&amp;M decreases)</td>
</tr>
<tr>
<td>3 Min. curve radius on line (e.g. ( \leq 400 ) metres; speed restrictions)</td>
<td>Speeds (km/hour); Vehicle lengths (m.)</td>
<td>Rail re-profiling/replacement; Loco &amp; rolling stock capital cost; Crew costs</td>
</tr>
<tr>
<td>4 Length of sidings or crossing/passing loops, e.g. 700 metres (44 wagons plus 2 locomotives)</td>
<td>Train trailing length (metres); No. of wagons/cariages</td>
<td>Unit operating costs (train length increases, unit O&amp;M decreases)</td>
</tr>
<tr>
<td>5 Locomotive drawbar capacity (tonnes)</td>
<td>Train trailing load; No. of wagons/cariages</td>
<td>Unit operating costs (train length increases, unit O&amp;M decreases)</td>
</tr>
</tbody>
</table>
Freight rolling stock

Container wagons

Double -stack container wagon (4 TEU)

Single tier container wagon (2 TEU)

General freight wagons

Bogie van or boxcar

Bulk freight wagons

Pneumatic Discharge Cement Wagon
Passenger rolling stock

Push-Pull DMU set in Sri Lanka

EMU set, Gyeongchun Line Rep.of Korea

Diesel locomotive hauled passenger train in India

Electric locomotive hauled passenger train in India
Assembly of unit operating cost data for input to model

- Some railway organizations maintain highly detailed data relating to physical parameters and costs
- One example is Indian Railways which makes available on its website “IR Statistical Statements” for various years up to and including most recent
- From this website it is possible to assemble accounting data (by Zonal Railway) and to compute all necessary unit operating cost data for input to the Traincost model
- Recent involvement in a coal haulage project in Pakistan enabled assembly of the following unit costs for PR and private operation

<table>
<thead>
<tr>
<th>S/N</th>
<th>UNIT COST ITEM</th>
<th>PR operation</th>
<th>Private operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Train crew cost per train hour (1)</td>
<td>1,238</td>
<td>764</td>
</tr>
<tr>
<td>2</td>
<td>Fuel consumption, Litres per '000 GTK (2)</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>3</td>
<td>Unit cost of diesel fuel, litre (3)</td>
<td>101.00</td>
<td>101.00</td>
</tr>
<tr>
<td>4</td>
<td>Unit cost of loco maintenance, per loco-km (diesel) (4)</td>
<td>167.15</td>
<td>125.42</td>
</tr>
<tr>
<td>5</td>
<td>Unit cost of wagon maintenance, per wagon km (5)</td>
<td>23.48</td>
<td>14.78</td>
</tr>
<tr>
<td>6</td>
<td>Variable cost of track maintenance, per GTK (6)</td>
<td>0.2256</td>
<td>0.2256</td>
</tr>
<tr>
<td>7</td>
<td>Fixed cost of route inf. maintenance, per track-km per year (7)</td>
<td>514,675</td>
<td>514,675</td>
</tr>
<tr>
<td>8</td>
<td>Station staffing cost per route-km per year (8)</td>
<td>882,957</td>
<td>882,957</td>
</tr>
<tr>
<td>9</td>
<td>Overheads as % of fixed and variable costs (9)</td>
<td>25%</td>
<td>10%</td>
</tr>
</tbody>
</table>

Sources:

Notes:
1. Train crew comprises a Driver, Assistant Driver and Train Guard
2. Fuel consumption for a 4,000 HP diesel-electric locomotive, with a hauling capacity of 2,400 tonnes on near level grade.
3. Based on retail price of diesel fuel near Karachi in early December 2014
4. Inclusive of the cost of scheduled overhauls, unscheduled repairs and running maintenance (lubrication, brake-block replacement, sanding, and fuelling)
5. Inclusive of the cost of scheduled overhauls, unscheduled repairs and running maintenance (eg lubrication, brake-block replacement)
6. Track maintenance cost which varies with the level of gross passing tonnage - principal cost components: rail replacement, ballast replacement
7. Inclusive of the fixed cost of track maintenance cost (principal daily inspection cost), as well as signalling and communications system maintenance
8. Inclusive of the salary and wages cost of: station staff, train control staff, and level crossing protection staff, all of which are regarded as fixed costs
9. Principal item is administrative overhead cost
............. Thank you for your kind attention!