Appendix 12: Risks in major infrastructure projects

This Appendix describes some evidence which has emerged in recent years about the extent of the risks involved in major infrastructure projects and makes some recommendations for changes of approach in future.

Past experience – the evidence

Table 31 summarises some international past experience in one sector – urban rail, based on Allport, (2002). The broad conclusion is that, with a few notable exceptions, not only have the capital costs been underestimated (typically by 50% to 100%) but operating costs have been routinely underestimated (by a factor of two or three times), while revenues have been overestimated (typically by 100%). This has occurred in widely different environments and procurement regimes and there is no evidence of improvement. Major urban rail projects seem to be inherently more risky than most other transportation projects.

Where?	Parameter	Outturn compared with Forecast	Source
Europe/North America	Capital cost	Average more than 50% worse	Merewitz, 1973
USA	Capital cost	" "	Wachs, 1986
Developing Cities	Capital cost Ridership	Half the projects 50% to 500% worse) Other half not as bad as this) Half the projects 50% to 90% worse) Other half not as bad as this)	Allport and Bamford, 1998
USA	Capital cost Ridership	From 17% to 156% worse) From 28% to 85% worse)	Pickrell, 1990
Worldwide	Capital cost Ridership	From 15% better to 500% worse) From 30% better to 90% worse)	Skamris and Flyvbjerg, 1996
Worldwide (Private Sector)	Capital cost Ridership	No improvement over public sector) " ")	Allport and Bamford, 1998
UK, USA	Ridership	2 out of 13 'successful'	Mackett and Edwards, 1998
Asia (Private Sector)	Capital cost Ridership	No improvement over public sector) " ")	Halcrow, 2000
Worldwide	Capital cost Ridership	From 46% better to 200% worse) (average 46% worse)) From 96% worse to 1% better) (average 51% worse))	Skamris, 2000
N. America,) UK)	Ridership	From 82% worse to 89% better) (8 selected systems))	Babalik, 2000

Table 31. Record of financial success for major urban (metro/LRT) projects

For other types of public works project, a paper by Flyvbjerg *et al.* (2002) reports that, for capital cost, 'other types of project are at least as, if not more, prone to cost underestimation as are transportation infrastructure projects'.

Other evidence comes from the UK public sector, where a report by consultants Mott MacDonald (2002) showed that inadequate records were often retained relating to the original forecasts, but the remaining evidence pointed to significant and systematic under-forecasting of capital costs. Mott MacDonald studied 50 major projects, each costing over £40 million, and compared their planned and actual capital costs. They found that the average optimism bias (i.e. the percentage by which outturn capital cost exceeded the capital cost estimated at the outset) was as follows:

- Non-standard buildings 51%
- Standard buildings 24%
- Non-standard civil engineering 66%
- Standard civil engineering 44%

The works also typically took longer than expected.

Mott MacDonald found that the top six causes of optimism bias for capital cost were

- inadequacy of the business case (much the most important cause)
- environmental impact
- disputes and claims
- economic factors
- late contractor involvement in design
- complexity of contract structure.

However, Mott MacDonald also found that the optimism bias for PFI/PPP projects was much less than for traditionally procured projects, since for PFI/PPP projects the business case was more highly developed and more project risks were identified and mitigated.

A UK project not studied by Mott MacDonald, because it was then still under construction, was the new Scottish Parliament Building in Edinburgh. It was finished in 2004, about three years late, and a public enquiry was held to try and establish why the capital cost rose from £50 million to £431 million. The official report of the enquiry blamed Scotland's civil service, saying that the worst decision they made was to opt for construction management, which meant designing the building as it was being built, with the consequence that no proper budget could be set. This was compounded by a number of other mistakes and cultural failures. The management of the project was the subject of an audit report published in June 2004, which stated that 'the normal financial discipline of named individuals being accountable for controlling expenditure within limits specified in an approved budget was not present on this project. It seems that project management regarded the regular reports from the cost consultant on construction costs and on risk costs as setting a construction budget, when they were no more than forecasts'. The audit report also concluded that 'the approach to risk management was not fully consistent with good practice'. Twelve risk workshops took place between October 2000 and December 2002. These identified owners for specified risks but 'there was no monitoring or feedback on subsequent action'. No further workshops were held after December 2002 and 'there was thereafter no systematic basis for any action by project management to manage out risk, although the cost consultant continued to report its assessment of the cost of risk in accordance with its terms of engagement'. The audit report concluded that 'the form of contracting must always be chosen with care, with a sound appreciation of the risks and benefits of each of the procurement options… In complex public sector projects, the client should ensure that there is a single point of control and leadership for the project, with explicit authority and responsibility given to the person in charge.'

A recent guide published by the British Department for Transport produced estimates for the optimism bias which (they stated) should be introduced into the appraisal for the capital cost of transport infrastructure projects. The study, which also cited previous work by the consultants involved, was based on data from 172 road projects, 46 rail projects, and 34 bridges and tunnels. About three-quarters of the roads data related to the UK, while the data for the other projects were mainly non-UK and drawn from North America and Europe. The data suggested that the probabilities of a cost over-run of at least 1%, 20%, 50% or 100% were approximately as follows:

Probability of a cost over-run of:

	1% or more	20% or more	50% or more	100% or more
Roads	80%	40%	5%	–
Rail	83%	75%	33%	–
Bridges/tunnels	70%	50%	20%	5%

The study concluded that, for new projects, the extent to which the estimated capital cost (including standard contingency allowances) should be increased in the appraisal to allow for optimism bias depended on the willingness to accept the risk of a cost over-run, as follows:

Risk of a cost over-run

	50%	10%
Cost uplift		
Roads	15%	45%
Rail	40%	68%
Bridges/tunnels	23%	83%

The report usefully identified the following specific causes for cost escalation in transport projects

- changed requirements such as speed, road width, road type
- changed routing
- changed safety norms or building norms
- tighter environmental standards
- complex or extensive works – e.g. water or mountain
- unexpected archaeological finds
- under-estimated expropriation costs
- complex interfaces (urban environment, links to existing infrastructure)
- new or unproven technology
- construction costs
- calculation approach failing to allow for unplanned situations
- delays due to weather
- appraisal optimism by interested parties – for example a tendency for local authorities to give priority to presenting the virtues of a given project rather than its risks, because cost over-runs fall thinly on the population nationwide whereas the benefits of the project are local.

The report stated, however, that the inclusion of optimism bias may be unnecessary if advanced risk analysis is applied:

'It may be argued that uplifts should be adjusted downward as risk assessment and management improves over time and risks are thus mitigated. It is however our view that planners and forecasters should carry out such downward adjustment of uplifts only when warranted by firm empirical evidence. For 70 years, optimism bias has been high and constant for the types of transport projects considered above, with no indication of coming down. With practices of optimism as deep-rooted as this, hard evidence from post-audits would be required to convincingly argue the case that optimism bias is finally coming down. In general, only such a time when this evidence is available should uplifts be reduced accordingly. Having stated this general rule and precaution it must be observed that individual projects may exist where the claims to improved risk mitigation are so strong that downward adjustment of uplifts is warranted in order to avoid double counting. This may be the case if advanced risk analysis (e.g. risk identification work shop and statistical calculations of volume and cost risks for individual project components) has been applied and their results adequately reflected in the established budget.'

We regard a proper application of RAMP, including independent checking of the parameters and models, as 'advanced risk analysis' which should render the inclusion of optimism bias adjustments unnecessary. We believe that it is far better to rely on 'advanced risk analysis' than optimism bias, because the project will then be fully thought through at the outset. There will be a proper study of the mitigation of downside risk and the maximisation of upside potential, which is likely to increase the chance of a good outcome. Merely relying on the application of an 'optimism bias' uplift to the capital cost in the appraisal loses this advantage and also runs the risk of rejecting

Sector		Revenue source	Operating costs important?	Exogenous factors[1] important?	Gov't imp'n action important[2]?	Competition important?	Tariff issues[3]?	Scale of operating risk[4]
Transport	Roads-expressways	Tolls	No	Yes	Yes	Modest	Yes	3
	Rail-metro/LRT	Fares	Very	Yes	Very	Very	Yes	5
	High-speed rail	Fares	Very	Yes	Very	Very	Yes	5
	Airports	Landing fees, retail etc.	Yes	Very	Yes	Modest	Yes	2-3
	Ports	Tariffs	Modest	Very	Modest	Modest/Yes	Varies	2
Water	Supply[5] and Sanitation	User tariffs	Modest	Modest	No	No	Critical	2-3
Drainage/flood Control	Drainage	No	No[6]	No	No	No	Na	1
	Flood defence	No		No	No	No	Na	1
Power	Generating plants	Take-off contracts	Very (fuel)	Very	No	No	No	1-2
	Distribution	User tariffs	Modest	Yes	No	No	Yes	2-3
Health and Education	Hospitals and Schools	Varies[7]	Modest	No	No	No	Generally no	1
Public		No	No	No	No	No	Na	0

[1] macroeconomic, political, social, demographic factors
[2] e.g. in project identification, land acquisition and permissions, and integrating the project
[3] the ability to raise tariffs periodically
[4] on a scale from 0 = unimportant to 5 = very important. This qualitative assessment follows from the previous columns in the table
[5] includes water resources development
[6] can be significant for pumped drainage
[7] often no payment, availability payments under PFI, or direct payment

Table 32. Operating risk characteristics of infrastructure sectors

worthwhile projects for no sufficient reason, as well as providing the project manager with a large contingency budget that reduces the incentive for efficient construction of the capital assets. Another advantage of RAMP is the emphasis it places on risk management, at the appraisal stage and onwards, of the project's income and expenditure once the asset has been constructed and comes into operation; these 'operating risks' are often at least as important as the risks of capital cost over-run.

Operating risks

Unfortunately there seems to be very little hard data about the totality of the operating risks which have been experienced in the past for major projects. This is unfortunate, since the risk events occurring once a project has come into operation can have a crucial impact on the success or failure of the project, often to a greater extent than a variation in capital costs. Table 32 summarises the characteristics of the operating risks in typical infrastructure projects, based on the experience of practitioners. Major urban rail projects are at one extreme, success requiring many factors to go right and being readily undermined by a single poor decision or adverse occurrence. Such projects always have an uncertain operating surplus or deficit, are dependent upon strong government action and support, and are subject to strong competition and regulatory risk. One success story was London's Victoria Line, an underground railway built in the 1960s, where it was recognised at the outset that there was not a viable financial case for building the line but construction was justified on the basis of the quantified 'social benefits' which would accrue to the wider community once it came into operation, and the line has proved a very worthwhile addition to London's tube network (see Beesley and Foster, 1963). At the other extreme, social infrastructure projects of a standard nature (such as hospitals and schools) tend to have less volatility in the eventual operating outcome compared with original expectations.

Forecasting operating risks

Operating risk occurs for many complex reasons and the scale and nature of the risks are not always appreciated at the outset. Too often the initial focus is dominantly on the huge task of completing the capital asset within budget and to time, and operating risks receive inadequate attention at that crucial point when the design can still be altered.

Practitioners' experience suggests that forecasts have often proved poor indicators of outturn operating results. The forecasting process is often complex and inherently uncertain, and as yet the uncertainties are rarely addressed with rigour. Some components are not always understood, for example rail operating costs. Forecasters may be motivated by a range of factors and they are not necessarily seeking to make a best estimate. Forecast revenues, in particular, are subject to very large margins of error. Operating forecasts are by their nature not verifiable until the project opens for business, and by that time corrective action may be able to have only a limited impact on commercial performance. The more flexible the design of the asset and the project as a whole can be, so as to permit changed modes of operation should this be necessary, the more likely it is that the initial operating performance will be satisfactory, even if circumstances have changed over the period (often of several years) since the design was decided upon. Moreover, a flexible design should be better able to adapt to changing and often unforeseeable circumstances over the period of many years during which it is hoped that the project will continue thereafter.

A need for change?

For social infrastructure of a standard nature (such as hospitals and schools) there may not need to be much change in existing practices relating to the forecasting and management of operating risks, though the use of a methodology such as RAMP should improve the chances of success significantly. In the case of other sectors, however, and notably in the transport sector, there may be a need for a radical change in approach, perhaps along the following lines:

- adapting the project development process and its staffing to serve the commercial needs of the project and its sponsors and investors;
- applying rigour in addressing risk and uncertainty, and drawing logical conclusions from this analysis (with the careful application of a methodology such as RAMP);
- not shrinking from taking account of 'social benefits, costs and risks' where necessary – i.e. benefits, costs and risks which will accrue to sectors of the community other than the project sponsors and can be quantified in financial terms – though there may sometimes be a political need to turn some of the social benefits into financial benefits for the sponsor, for example by levying development charges on new buildings which will benefit from the project's improved infrastructure;
- providing a 'reality check' on forecasts produced by sophisticated models, by analysing the real-world experience of comparable projects and introducing independent checking of the parameters used;
- using independent audits and peer reviews by acknowledged experts, of the business case and the whole appraisal and risk management process, including the investment model, before irrevocable decisions are taken;
- building flexibility into the asset design and the project as a whole, even at extra cost, so as to allow the sponsor to respond flexibly to changing circumstances for many years into the future.

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(**Note:** the main bibliography is on page 71)

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