Australian Transport Assessment and Planning Guidelines

O2 – Optimism Bias

May 2018

Contents

Table of Figures:

Optimism bias

At a glance

- Optimism bias in infrastructure planning and assessment can result in costs tending to be under-estimated and/or demand (and hence benefits) over-estimated.

- This results in:

    – Over-estimation of net benefit results in cost-benefit analysis

    – The delivery costs of initiatives exceeding the pre-delivery expected costs, leading to budgetary stress

    – An erosion of the public's confidence in infrastructure planning, assessment and delivery processes.

- This guidance highlights practices for ensuring that optimism bias is minimised or avoided in cost estimation, demand forecasting, benefit identification and estimation, resulting in more reliable cost-benefit analysis results. Practices include:

    – Having an awareness of the risks of optimism bias

    – Using the best available data, and best practice techniques, for estimating costs and demand

    – Having a transparent understanding of the assumptions underpinning the estimation processes

    – Comparing estimates with evidence from elsewhere

    – Using independent peer reviews

    – Testing the robustness of results through sensitivity testing and (where feasible and justified) probability-based analysis.

- If there is evidence of optimism bias in cost and/or benefit estimates in a proposal, then sensitivity testing using cost uplifts or downward adjustments to benefits in the CBA should be undertaken.

There is a close link between the guidance presented here and the Cost Estimation Guidance Notes published by the Australian Government Department of Infrastructure and Regional Development[1] (to be summarised in Part O1 of the Guidelines). They should be read concurrently in relation to infrastructure costs.

1.   Introduction

The cognitive bias known as optimism bias is the tendency to underestimate the likelihood of experiencing adverse events. For example, smokers may feel that they are less likely than other individuals who smoke to develop lung cancer, and motorists may feel they are less likely to be involved in a car accident than the average driver.

In the context of the infrastructure planning and assessment process, optimism bias can result in a scenario whereby costs tend to be under-estimated and benefits over-estimated by the appraisal team. This may result in:

- An over-estimation of the net benefits[2] of initiatives in the ex-ante (pre-delivery) planning stages compared with ex-post (after delivery). This may lead to: initiatives proceeding (or initiatives in the delivery stage being allowed to continue) that would not have passed the appraisal process had the bias not occurred; and biased ranking of initiatives.

- A concerning pattern of delivery costs of initiatives exceeding the pre-delivery expected costs, leading to budgetary stress

- An erosion of the public's confidence in infrastructure planning, assessment and delivery processes.

In recent decades, researchers have claimed that optimism bias is a worldwide problem, particularly with regard to transport infrastructure, with evidence arising largely through the work of Danish economic geographer Bent Flyvbjerg and colleagues (e.g. Flyvjberg 2009, Flyvyberg 2012 and other citations in references section). In 2002, Flyvbjerg et al. (2002) claimed that of 258 transport initiatives, the actual capital cost of road and rail initiatives was, on average, 20 to 45 per cent more than estimated. In a later study of 210 transport initiatives, the same authors (2006) claimed that actual patronage for rail initiatives was 49 per cent of forecast patronage.

The Productivity Commission (2014) makes a number of relevant points. Optimism bias occurs when overly favourable estimates of net benefits are presented as the most likely or mean estimates. They note that this could occur as a result of overestimating future benefits (often linked to an unrealistically high estimate of the annual rate of growth of benefits) or underestimating future costs (often linked to excluding relevant costs) (DFA 2006). A UK report claims that optimism bias is an endemic problem associated with cost-benefit analysis (CBA) (DFA 2006, UK Government 2011).

---

[1] Refer: http://investment.infrastructure.gov.au/whatis/costestimation/index.aspx

[2] As measured by net present value (NPV) and benefit cost ratio (BCR).

The Productivity Commission (2015) has further reinforced its concerns by observing that "*There is a systematic tendency for project appraisers conducting cost-benefit analysis to be overly optimistic — the bias is toward overstating benefits, and understating timings and costs, both with respect to initial capital commitment and operation costs. Over estimates of traffic forecasts on toll roads and tunnels are a particular problem.*"

Having raised concerns about optimism bias (UK DfT 2004 and subsequently), the UK Department for Transport introduced 'cost uplifts' over 10 years ago to attempt to combat cost overruns on projects. The UK Government attributed the cost overruns to over-optimism by project sponsors and estimators. It was during this period that Flyvjberg (see above) flagged optimism bias as a particular problem regarding transport infrastructure initiatives. In 2011 the UK Treasury (2011, 2013) used its Green Book guidance to also promote the use of uplift factors to deal with optimism bias in cost estimates.

Cost uplifts and downward adjustments of benefits as per the UK Treasury are not presented as the primary approach for minimising optimism bias here in the ATAP Guidelines. Chapter 3 below, which presents a wide range of recommended actions, includes the use of cost uplifts or downward adjustments to benefits only via sensitivity testing when evidence of optimism bias is prominent. While an outside view such as benchmarking against a reference set of projects is important and should form part of the estimate validation process, applying 'cost uplifts' based on past projects is arguably not a long-term solution because it does not address the root cause. This is because such an approach does not attempt to predict specific uncertainties, but simply places a given project in the statistical distribution generated from the reference set. This means it leaves no scope or incentive for estimators to improve their practice; they will simply refer to past data to estimate the required contingency.

Accordingly, the ATAP Guidelines sees the solution to combating optimism bias lying in long-term process improvement. Robust cost and benefit estimation methodology, tested and validated over time, combined with a rigorous independent review process and policy settings providing incentives for project proponents to submit accurate and realistic benefit and cost estimates, are more likely to address optimism bias (and other biases more generally) in a proactive and constructive way.

It should be noted that a range of biases can arise when generating estimates of benefits and costs, with optimism bias being only one (see discussion in Appendix A).

2. Causes of optimism bias

Optimism bias is a result of human and institutional behaviour typically associated with under estimation of costs and over estimation of benefits. The following are likely drivers of optimism bias:

- A natural cognitive optimism in people's decision-making

- A failure to consider adequately what can go wrong during the planning, assessment and development of initiatives

- Insufficient incentives to ensure decision-makers present unbiased most likely outcomes

- Implicit incentives to understate investment costs down to improve CBA and financial results

- Decision-making processes and strategic behaviour that favour implementation of large, capital intensive initiatives (UK Department for Transport 2004).

- Cases where the beneficiaries and proponents of an initiative provide only a limited proportion of the funds required for the initiative

- The influence of special interest groups.

3. Recommended actions

Best practice techniques to estimate projects costs[3] and benefits are likely to significantly reduce or avoid the various forms of bias related to infrastructure planning and assessment. The following is a recommended list of actions aimed at ensuring that optimism bias is minimised in Australian transport.

General:

- Be aware of the existence of optimism bias, and build in checks in processes to address this and other forms of bias

- Use the best available data to support cost estimation, demand estimation and CBA

- Use appropriate techniques to estimate costs[4] and demand, and compare estimates against evidence from other initiatives and places. In undertaking comparisons, it is vital that analysts not simply seek corroborating evidence, but identify a range of other experiences and calibrate their own estimates relative to the general experience

- Use independent peer reviewers to verify that cost and demand estimates are realistic

- Undertake risk workshops wherein the main stakeholders and people with knowledge of the project and/or the potential risks involved review the assumptions made and the risks. Using their personal judgement, workshop participants evaluate known risks, including developing probability distributions, and identify and evaluate any additional risks that may have been missed (including identifying mitigation strategies) (Napier & Liu 2008)

- Undertake sensitivity analyses by applying uplifts to costs and / or downward adjustments to benefits in the CBA

- Having strict controls on changes in project scope and modifications to the project's specifications

- Where there is co-funding of projects, ensuring the entity responsible for scope changes or modifications bears some of, if not all, the cost consequences

- Undertake routine post-completion reviews that compare demand and cost that actually eventuate with estimates used in the decision to proceed with an initiative

For CBA (in addition to the above):

- Use the most likely or 'expected value' CBA results (based on most likely inputs) as the central (most likely) scenario of a CBA

---

[3] For cost estimation, they include the probabilistic method, and also rigorous deterministic methods. See Part O1 of the Guidelines on Cost Estimation for further details.

[4] See the Department for Infrastructure and Regional Development Cost Estimation Guidance Notes – as discussed in Part O1 of the ATAP Guidelines.

- In identifying the benefits of an initiative for use in CBA, be careful that double-counting between benefits does not occur (e.g. from counting secondary or transferred or flow-on benefits on top of direct benefits). Any double-counting should be removed from a CBA.

The following three actions were suggested by the Productivity Commission (2014):

- Use sensitivity analysis to test the robustness of outcomes to changes in variables or assumptions

- Provide a clear statement of the assumptions underpinning the analysis and reasons for those assumptions to increase the amount of information held by the decision-maker, and reduce the likelihood of them being misled and allowing for an independent analysis of the results (DFA 2006)

- Identify results of comparable projects carried out elsewhere (Dobes 2016) – also called *reference class forecasting* [compare forecasts against actual observations from a reference class of comparable situations (BITRE 2011)] – to provide a point of comparison by examining the outcomes of comparable past projects (OECD/ITF 2013)

For Cost Estimation:

- Use the Cost Estimation Guidance Notes[5] published by the Department of Infrastructure and Regional Development – see ATAP Part O1 on Cost Estimation for further discussion

- Take particular care to identify all possible costs that will be incurred and make appropriate allowances for them

- Ensure in particular that the 'base estimate' in cost estimation is developed in a robust manner (due to its critical role)

- Be aware that financial risks associated with optimism bias are especially a problem for initiatives involving major 'sunk cost' investments in public transport infrastructure. Sunk costs (e.g. fixed infrastructure) cannot be reversed. On the other hand, non-sunk costs (e.g. buying an extra bus) can be reversed by selling the asset. The cost penalty of incurring sunk costs is therefore much higher than incurring non-sunk costs. Accordingly, if optimism bias leads to a bad investment decision, the associated cost penalty (i.e. financial risk) is greater with sunk costs than non-sunk costs.

- Use a probabilistic approach to cost estimation for all major initiatives, and wherever possible otherwise. The Australian Government mandates the use of probabilistic estimates for initiatives above $25 million in capital value. In cases where a deterministic costing method is used, ensure that a rigorous approach is followed (see Part O1 on Cost Estimation for further discussion)

- Apply rigorous contingency management principles to ensure greater discipline on cost control.[6]

---

[5] Refer: http://investment.infrastructure.gov.au/whatis/costestimation/index.aspx

[6] The alternative approach of simply reducing contingency budgets as an incentive for more disciplined cost control is risky — it could lead to dysfunctional behaviour such as adding fat to the base estimate and/or the contingency allowance, and even 'gold-plating' of early designs in order to maximise the budget knowing the that the scope (and therefore cost) can later be reduced to stay within the allocated budget, with such dysfunctional behaviours then creating the conditions for gaming the system (Hollman, 2016).

For Demand Estimation:

- Check the realism of the demand forecasts over the appraisal period (having regard to the dangers of optimism bias)

- Ensure consistency of demand estimates between the Base Case and the Project Case

- Ensure when estimating the most likely CBA results, that the most likely demand estimation inputs are used – including the most likely (medium) population and land use assumptions. The use of high scenario population projections should be limited to sensitivity tests, where variations from most likely inputs are considered

- Use reference class forecasting of demand estimates (BITRE 2011)

- Downward adjustments of estimates based on past experience (BITRE 2011).

The following sources provide further discussion of rigorous demand estimation and avoiding biased estimates:

- Department of Infrastructure and Regional Development (2017) – provides links to the series of reports resulting from an Australian Government review of patronage forecasting optimism and risks observed in toll roads in Australia

- The work of Robert Bain (University of Leeds) (Bain 2017) a renowned expert.

Part T1 of the Guidelines provides guidance on rigorous travel demand modelling.

Probability analysis:

- When using probability analysis to estimate costs and or benefits, use realistic and likely probability distributions rather than simply assuming a normal distribution applies for all variables

- Use sensitivity tests of key input variables to test the sensitivity of demand forecasts. An even more rigorous approach involves using a probability-based approach for estimating forecasts of demand and associated outcomes (e.g. revenue) as suggested by the US FHWA (2016) (see Appendix B for a brief discussion).

When agencies that make funding recommendations and review funding proposals have concerns that an initiative may be subject to optimism bias, they may consider scaling down the CBA results to reflect what they consider to be more realistic results. It is hoped that with continued improved practices in cost estimation, demand estimation and CBA to counter optimism bias as outlined above that the need for such practices by funding agencies will decline.

Appendix A   Context – Bias in estimates

There are many forms of bias, with optimism bias being one of them. Best practice in planning and assessment requires an unbiased process, with all forms of bias being monitored and managed.

Consider cost estimation for example. When project costs are being estimated, the most likely cost for any particular item is only one of a range of potential outcomes. Costs are statistical in nature and best characterised by a probability distribution which, from historical data or an estimator's experience, represent the expected range and probabilities that the cost item will take.

Estimating the cost of an infrastructure project, or its expected benefits, almost invariably involves some element of subjective estimation. Obtaining data from which to determine the uncertainty of all of the variables within the model, so that subjective assessments are not needed, is usually not possible because:

- The data have never been collected in the past
- The data are too expensive to obtain
- Past data are no longer relevant, and/or
- The data are sparse.

The majority of the subjective assessments to be made regard uncertainties that could take a range of values as shown below.
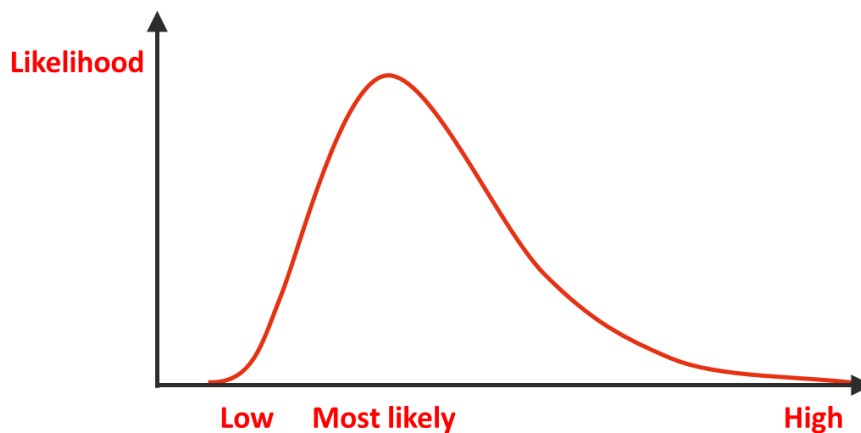

Figure 1 - The range of values associated with uncertain outcomes

Distribution parameters are usually assessed in terms of three-point estimates of low, most likely and high possible outcomes for the value concerned. The distribution used represents what those who produce it believe about the value it represents. It is not an engineering measurement or data derived from scientific observations. It is an informed opinion.

The process of extracting and quantifying individual judgement about uncertain quantities is known as probability encoding and has been the subject of considerable academic research for decades (Spetzler & Stael von Holstein 1975). There are many ways to analyse and describe the way human assessments can be affected by both unconscious and by deliberate bias. These can be summarised as:

Optimism

There may be many reasons for a project team, or project proponents, wanting to see a project accepted for implementation, and some people simply prefer to adopt an optimistic view of the future – which can include failure to consider what can go wrong, and assuming business-as-usual or that the future will be like the past.

In relation to costs, this can lead to understating the base estimate and the amount of variation that might arise, especially when assessing variations that will tend to drive up cost. The same is also true of benefits, with the outcome being over-stating of benefits, for example of demand forecasts and travel time savings. The two effects reinforce each other leading to overly optimistic estimates of the net benefits arising from the cost-benefit analysis.

Availability

People make assessments based on the information they have at hand. They will rarely take deliberate steps to seek out information from other settings that might conflict with what is most readily available. This can lead to the potential for major deviations from planned costs, and/or forecast benefits, to be overlooked or set aside even when evidence from other areas would raise serious concerns.

Confidence

People involved in projects tend to believe in their ability to deliver projects. Training and culture generally encourage a positive attitude. This may be at odds with an objective assessment of the real prospects of a piece of work being delivered to plan.

Anchoring

Once a cost or a benefit has been declared, assessments of possible variation from that value will tend to remain close to that starting point. This results in a systematic tendency to understate the extent to which actual outcomes could differ from the assumptions incorporated into an estimate, whether they will raise or lower the cost or raise or lower benefits. The assessment is anchored on the initial estimate.

In relation to cost estimation, the Australian Department for Infrastructure and Regional Development's (2017) cost estimation guidance[7], outlines a rigorous approach to limit or avoid bias during the estimating process. The approach has two main parts:

- Establishing the context of the assessment, and

---

[7] Being released as a series of Guidance Notes refer: http://investment.infrastructure.gov.au/whatis/costestimation/index.aspx.

- Assessing quantitative measures of a possible variation.

Establishing the context increases the chances that participants in the process will take account of all relevant information and offers all a chance to arrive at a common understanding of what is being assessed. It helps to address biases arising from limited information and unrealistic optimism or pessimism. Established techniques also exist to address other forms of bias, and these are explored and explained within the DIRD's guidance.

Appendix B   Probability-based demand forecasts

The FHWA (2016) discuss how Quantified Probability Analysis (QPA) can be used to provide decision-makers a probability distribution of possible outcomes. Although it specifically considers the case of toll roads, the method can be generalised. A brief summary follows.

QPA enables participants in an infrastructure initiative project, such as developers, government agencies, financiers and other stakeholder, to be satisfied that their (possibly differing) demand and benefits (or revenue forecast in the case of toll roads) are properly addressed.

QPA requires expert transportation planning and statistical capabilities. It first recognises and quantifies inherent uncertainties in the modelling and forecasting process. Specific steps are:

1. Clear identification and assessment of factors that could significantly affect travel demand and associated outcomes (such as project revenues in the case of toll roads)

2. Development, using analysis or judgment, of the probability distribution for each of these factors individually

3. Combination of these probability distributions for significant input factors to produce a single overall probability distribution function for traffic estimates and associated outcomes.

The probability distribution can then be used to identify various outcome values, for example:

- The expected value, which is the 'central' or 'most likely' case

- The variance

- Confidence intervals, for example, at 90 per cent

- Other values requested by project participants for their risk assessments and financial models.

Numerous input variables for the modelling process need to be screened and selectively analysed, including:

- Toll rates or public transportation fares

- Perceived traveller value of time

- Regional transportation network characteristics and changes

- Land use types, intensities, patterns and trends

- Socioeconomic parameters (population, employment, etc.)

- Modal splits and trip purpose mix

- Energy costs/environmental constraints.

References

Bain, R 2017, *RBconsult – Articles and papers*, http://www.robbain.com/articlesandpapers.htm , accessed 28 June 2017 (see list of specific Bain references on optimism bias below)

BITRE (Bureau of Infrastructure and Regional Economics) 2011, *Review of traffic forecasting performance of toll roads*, Australian Government, https://infrastructure.gov.au/infrastructure/infrastructure_reforms/files/Attach_A-BITRE_Literature_Review.pdf

Department of Infrastructure and Regional Development 2017, *Patronage risk*, https://infrastructure.gov.au/infrastructure/infrastructure_reforms/patronage_risk.aspx (accessed 28 June 2017)

Department of Infrastructure and Regional Development 2017, *Cost Estimation Guidance* http://investment.infrastructure.gov.au/whatis/costestimation/index.aspx

DFA (Department of Finance and Administration) 2006, *Handbook of Cost-Benefit Analysis*

Dobes, L 2016, *Social Cost-Benefit Analysis in Australia and New Zealand*

Flyvbjerg, B 2005, 'Measuring inaccuracy in travel demand forecasting: Methodological considerations regarding ramp-up and sampling', *Transportation Research Part A: Policy and Practice*, 39(6), 522-530.

Flyvbjerg, B 2007, 'Cost Overruns and Demand Shortfalls in Urban Rail and Other Infrastructure', *Transportation Planning and Technology*, vol. 30, no. 1, pp. 9-30.

Flyvbjerg, B 2008, 'Curbing Optimism Bias and Strategic Misrepresentation in Planning: Reference Class Forecasting in Practice', *European Planning Studies*, vol. 16, no. 1, pp. 3-21.

Flyvbjerg, B 2009. 'Survival of the unfittest: why the worst infrastructure gets built — and what we can do about it', *Oxford Review of Economic Policy* 25(3): 344–67.

Flyvbjerg B 2012, 'Quality control and due diligence in Project Management: getting decisions right by taking the outside view', *International Journal of Project Management*

Flyvbjerg, B Bruzelius & N, Rothengatter, W 2003, *Mega Projects and Risk: An Anatomy of Ambition*, Cambridge University Press, Cambridge.

Flyvbjerg, B Holm, M K S & Buhl, S L 2003, 'How common and how large are cost overruns in transport infrastructure projects?' *Transport Reviews*, *23*(1), 71-88.

Flyvbjerg, B, Holm, M K S & Buhl S L 2006, 'Inaccuracy in Traffic Forecasts', *Transport Reviews*, *26*(1), 1-24.

Hollmann, J 2016, *Project Risk Quantification: A Practitioner's Guide to Realistic Cost and Schedule Risk Management*, Probabilistic Publishing, Gainesville, FL

Infrastructure Risk Group 2013, *Managing Cost Risk & Uncertainty In Infrastructure Projects - Leading Practice and Improvement:* http://www.ice.org.uk/Information-resources/Document-Library/Managing-Cost-Risk---Uncertainty-in-Infrastructure

Napier, Z & Liu, L 2008, 'The predictive validity and performance drivers of risk-based estimating: case studies of Australian water infrastructure projects', paper presented at *PMI® Research Conference: Defining the Future of Project Management*, Warsaw, Poland. Newtown Square, PA: Project Management Institute

OECD/ITF (Organisation for Economic Co-operation and Development/International Transport Forum) 2013, *Better Regulation of Public Private Partnerships for Transport Infrastructure, ITF Round Tables,* Report No. 151.

PC (Productivity Commission) 2014, *Public Infrastructure*, Inquiry Report No. 71, Canberra

PC (Productivity Commission) 2015, *PC Productivity Update2015* http://www.pc.gov.au/research/ongoing/productivity-update/pc-productivity-update-2015/3-improving-the-efficiency-of-capital-investment-in-public-infrastructure

Spetzler & Stael von Holstein 1975, 'Probability Encoding in Decision Analysis', *Management Science* 22(3), 340-58

UK Treasury 2011, *The Green Book: Appraisal and Evaluation in Central Government*, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/220541/green_book_complete.pdf

UK Treasury 2013, *Green Book supplementary guidance: Optimism bias*, https://www.gov.uk/government/publications/green-book-supplementary-guidance-optimism-bias

UK Department for Transport 2004, *Transport Analysis Guidance—webTAG.* http://www.webtag.org.uk

UK DfT (Department for Transport) 2014, *TAG Unit 1.2: Scheme Costs UK Department for Transport 2003,* http://www.webtag.org.uk/webdocuments/3_Expert/6_ Accessibility_Objective/3.6.1.htm (accessed 8 August 2014)

US FHWA (Federal Highway Administration) 2016, *Guidebook on Financing of Highway Public-Private Partnership Projects,* https://www.fhwa.dot.gov/ipd/p3/toolkit/publications/guidebooks/financing_of_highway_p3_projects/appendices.aspx

List of Optimism Bias References in Bain (2017)

Bain, R 2017, 'Better Traffic Forecasts?', *Infrastructure Investor*, Issue 81, 38-41, April 2017, PEI Media Ltd, London

Bain, R 2015, 'Ethics and Advocacy in Forecasting Revisited: Consultants in the Dock', *Local Transport Today*, LTT 680, 4 - 17 September 2015, London

Bain, R 2013, 'Toll Roads: Big Trouble Down Under', *Infrastructure Journal*, 17 January 2013, London

Smith, N, Bain, R & Kanowski, S 2011, *An Investigation of the Causes of Over-Optimistic Patronage Forecasts for Selected Recent Toll Road Projects*, GHD (for the Australian Department of Infrastructure and Transport), December 2011, Sydney

Bain, R 2011, 'On the Reasonableness of Traffic Forecasts: A Survey of Predictive Capability', *Traffic Engineering and Control*, Vol. 52, No. 5, May 2011, 213-217

Bain, R 2009, 'Error and Optimism Bias in Toll Road Traffic Forecasts', *Transportation*, Vol. 36, No. 5, September 2009, Springer, Netherlands

Bain, R 2009, *Toll Road Traffic & Revenue Forecasts: An Interpreter's Guide*, ISBN 978-0-9561527-1-8, April 2009

Bain, R 2009, 'Big Numbers Win Prizes: Twenty-One Ways to Inflate Toll Road Traffic & Revenue Forecasts', *Project Finance International*, Issue 406, 8 April 2009, Thomson Reuters, London

Bain, R & Polakovic, L 2005, *Traffic Forecasting Risk Study 2005: Through Ramp-Up and Beyond*, August 2005, Standard & Poor's, London

Bain, R & Plantagie, J W 2004, *Traffic Forecasting Risk: Study Update 2004*, October 2004, Standard & Poor's, London

Bain, R & Plantagie JW 2003, *Traffic Forecasting Risk: Study Update 2003*, November 2003, Standard & Poor's, London

Bain, R & Wilkins, M 2002, *The Credit Implications of Traffic Risk in Start-Up Toll Facilities: Appendix – Traffic Risk Index*, September 2002, Standard & Poor's, London

Bain, R & Wilkins, M 2002, *The Credit Implications of Traffic Risk in Start-Up Toll Facilities*, August 2002, Standard & Poor's, London