New Submission to Inquiry into Effective Decision Making for the Successful Delivery of Significant Infrastructure Projects
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Inquiry Name: Inquiry into Effective Decision Making for the Successful Delivery of Significant Infrastructure Projects

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Public Accounts and Estimates Committee

Submission No. 2

SUBMISSION CONTENT:

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Hi

My professional area of interest is decision-making in the specific context of transportation investments (particularly large road and rail projects). In the attached paper I revisit the role of transportation modelling in the demand/revenue forecasting process and suggest some changes which could benefit decision makers. I'd be happy to discuss this matter further with the Committee if/as required.

Kindest regards,

Rob Bain
UK

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File1: 4e8adbb9d49ea-Rethinking the Traffic Forecasting Process.pdf

File2:

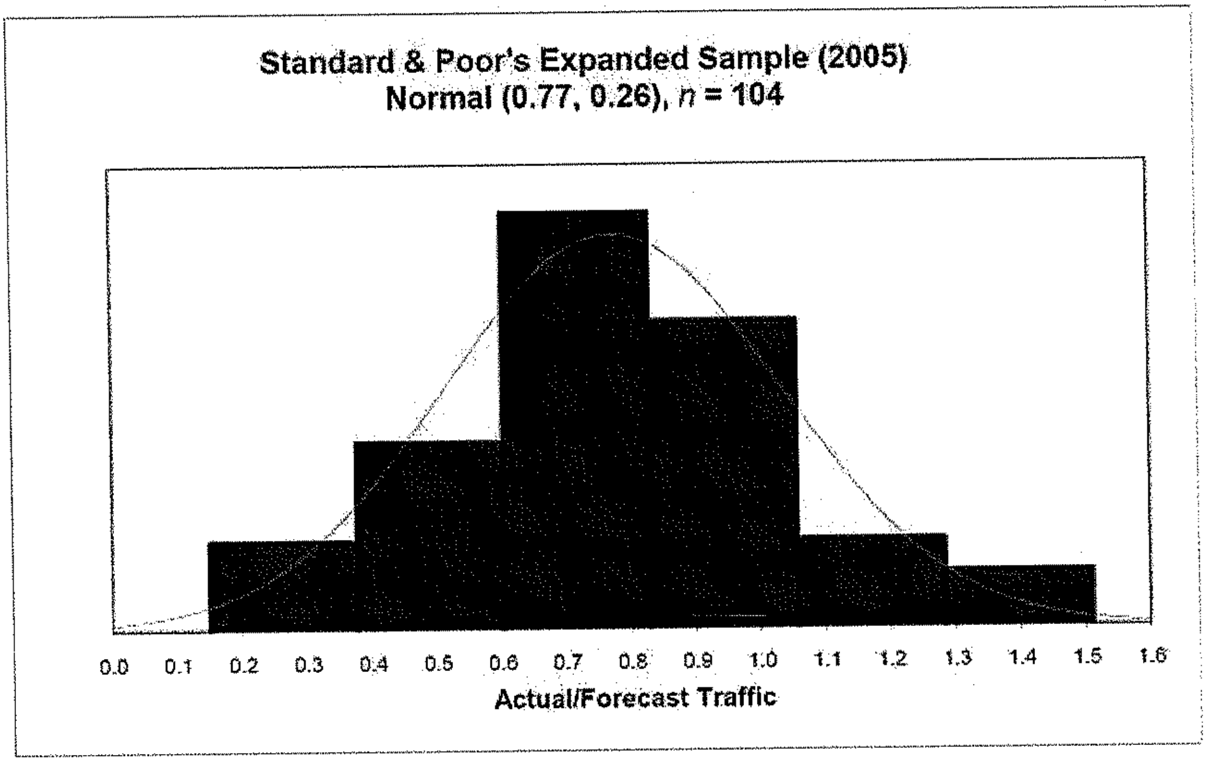
File3:

Appendix A

Rethinking the Traffic Forecasting Process

This report has focused on forecasting bias; in particular optimism bias. However optimism bias is but one characteristic of toll road traffic and revenue forecasts. The other is error – and as a number of authors have pointed out, forecasting errors are common and are commonly large; see, for example, JP Morgan (1997), Flyvbjerg et al (2005), Li & Hensher (2009) and Bain (2009). The Figure below – taken from Bain (2009) – shows both the influences of bias and error. Forecasting performance, along the horizontal axis, is presented in terms of the ratio of actual-to-forecast traffic. The mean of the distribution sits to the left of 1.0 reflecting bias (over-optimism). The spread of the distribution reflects error. From Figure A1 it can be seen that the forecasting errors range from 85% below the actual (outturn ie. observed) traffic volume to 50% above it. This is indeed a wide range

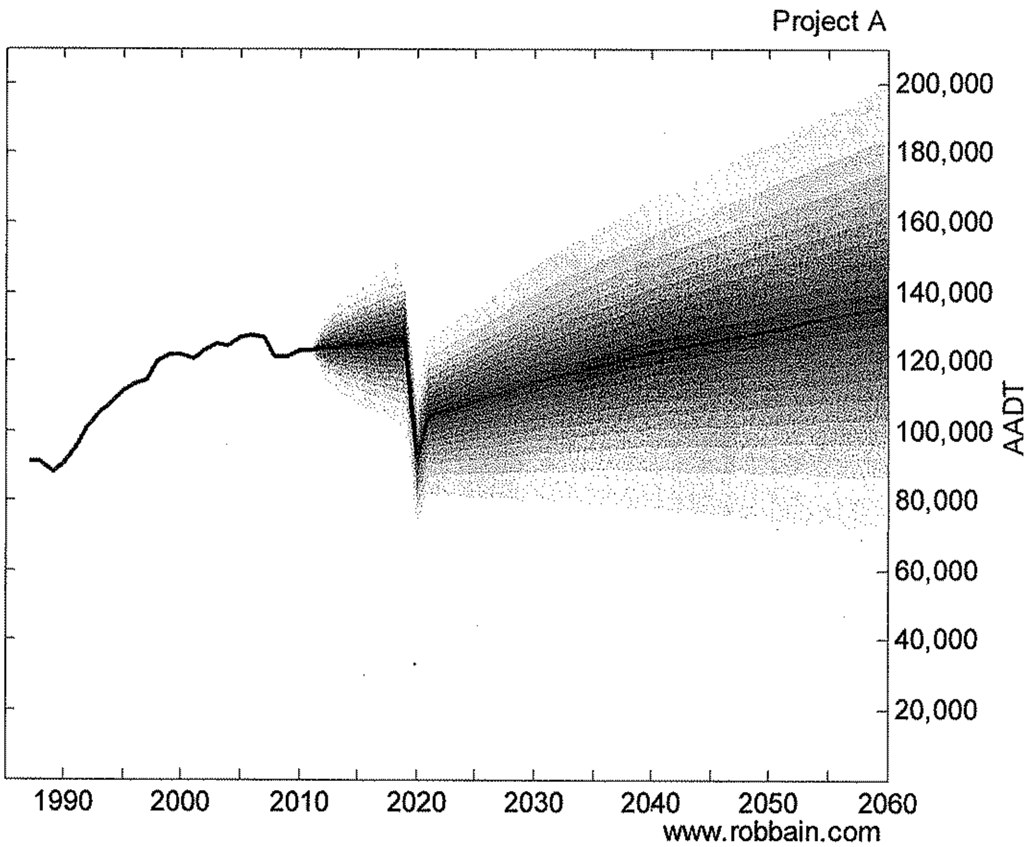
Figure A1: Error and Optimism Bias in Toll Road Traffic Forecasts



Flyvbjerg (*op cit*) highlights the fact that, from his research, there appears to have been no improvement in traffic forecasting accuracy over the years. Initially this seems counter-intuitive; given the increasing sophistication of forecasting models and the enhanced scrutiny brought to bear on forecasts by private investors with 'real money' at risk. However perhaps we are expecting too much – in terms of accuracy – from traffic forecasts? Other research has focussed on the sources of forecasting error; see Zhao & Kockelman (2002), de Jong et al (2007) and Bain (2011) – and has concluded that the errors associated with the models themselves (sampling error, misspecification error etc.) are small in comparison to the errors associated with the model inputs (projections of population, employment, income, car ownership, fuel price and so forth). This suggests that – irrespective of model sophistication (and the extent of resource devoted to the modelling process) – there is a certain 'upper level' of traffic forecasting accuracy beyond which models would be unlikely (on average) to perform.

Bain takes his findings from (a) a trend analysis of past traffic forecasting performance, (b) a state-of-the-practice survey of transport modellers (asking specifically about predictive capability) and (c) an examination of the uncertainty associated with population forecasts (a – if not the – key input to traffic forecasts) and derives evidence-based prediction intervals for traffic forecasts. An example is shown in Figure A2. The key take-away is that the prediction intervals are likely to be large, and get larger as the traffic forecasting horizon extends.

Figure A2: Evidence-Based Prediction Intervals for Traffic Forecasts



At first glance, aside perhaps from the size of the prediction intervals, there appears to be nothing particularly new about Figure A2. Some traffic consultancies have, for a number of years, been presenting ranges or confidence intervals around their central case forecasts.

However closer examination of the 'confidence intervals' presented by traffic consultants in their reports suggests that they are commonly:

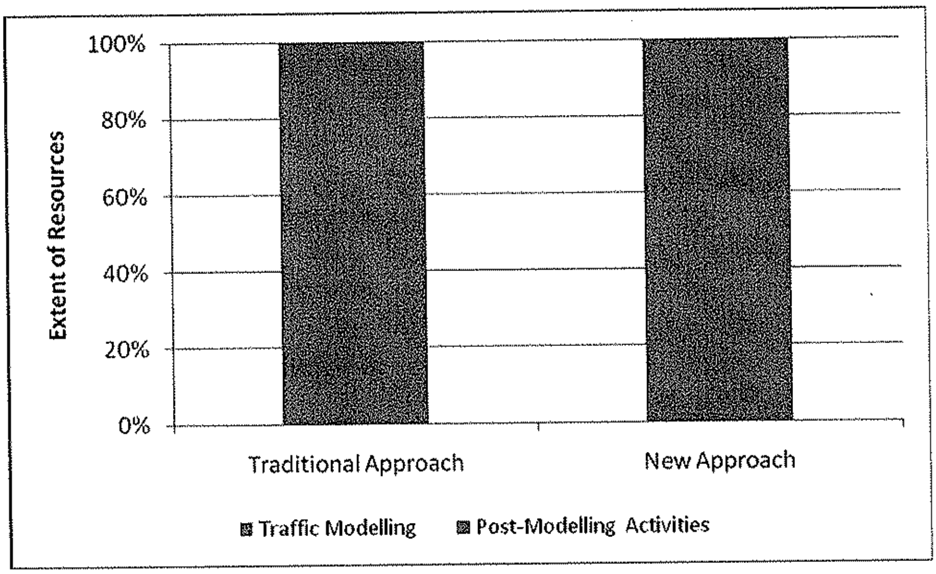
- Simply 'guesstimates' (eg. ±10%), or
- High and low estimates (derived from high and low growth scenarios), or
- The results from selective/sample sensitivity tests, or
- The results from selective/sample probability modelling.

Analysis of the 'confidence intervals' reported by others leaves the reader with the strong impression that they have been crafted in ways that seek to emphasise the 'confidence' that can be placed on central case predictions. It is not uncommon to observe the presentation of unfeasibly narrow prediction intervals around base or central case forecasts and to be left with the feeling that they are being used as some sort of 'sales pitch'. In contrast, the prediction intervals shown in Figure A2 are empirically-derived from the three, independent sources listed earlier.

The empirically-derived prediction intervals shown in Figure A2 represent the starting point from which Bain (unpublished) proposes a different approach to traffic forecasting and working with forecasting models.

Figure A3, to the left, indicates the extent of resources typically devoted to modelling and post-modelling activities in a traditional toll road traffic and revenue study. The percentages are shown for illustration purposes only. The process is dominated by modelling with post-modelling activities (such as reviewing the model, testing and checking the outputs, running additional sensitivity tests etc.) playing a relatively minor role. Bain challenges this approach – based on the explicit recognition of the limitations of modelling (mentioned above) – and places far greater emphasis on post-modelling activities.

Figure A3: Resources Devoted to Modelling and Post-Modelling Activities

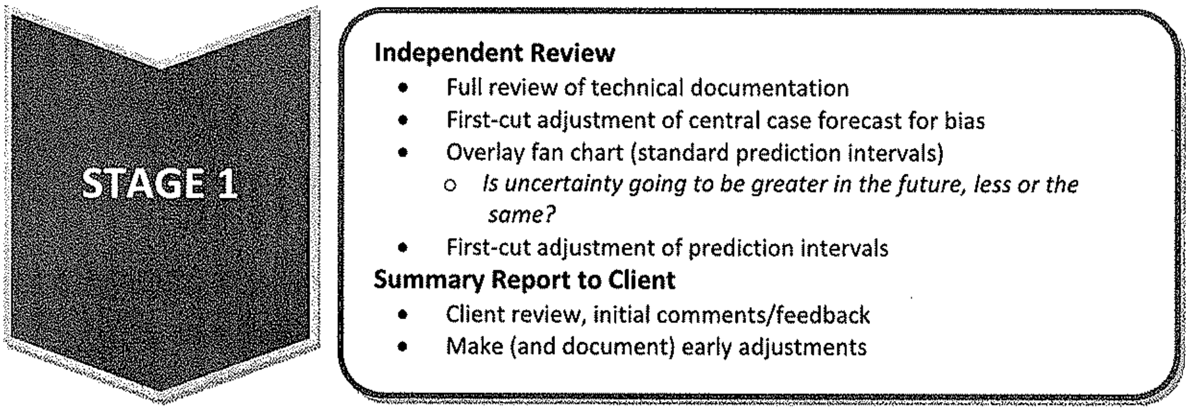


Bain's approach derives from work he conducted for highly-experienced institutional investors (from North America) who – based on past performance – are generally sceptical of the capabilities of state-of-the-practice traffic forecasting models. It also builds on forecasting practice from other disciplines (economics and finance) where models are used to inform a process specifically acknowledged from the outset to represent a <u>blend</u> of modelling, statistical analysis, data mining, knowledge, experience and judgment.

Over the past two years, Bain has developed, implemented and refined a 4-stage framework to encapsulate and formalise post-modelling activities. As will be seen, the fourth stage is an option specifically developed for private financiers (with limited relevance for public sector procuring agencies). Nevertheless, for completeness, the 4-stage framework is outlined in full in the following text.

Stage 1 of the process is described in Figure A4. It starts with an independent technical review of the modelling work conducted (and reports produced) to date. Two actions flow from this review. First the central case forecast is adjusted to eliminate any suspected bias. Second, a 'fan chart' (like the one in Figure A3) is superimposed on the adjusted central case forecast.

Figure A4: Post-Modelling Activities – Stage 1



Bain's research extends work undertaken by the UK Department of Transport (DfT, 2011) which estimated that the prediction intervals associated with national traffic forecasts could be approximated by the formula:

$\pm 2.5\% * \sqrt{n}$ ...where n is the number of years ahead

So, for example, the prediction interval (around a central case forecast) in Year 16 would be expected to be:

$\pm 2.5\% * \sqrt{16}$ ...ie. ±10%

Bain's work on local traffic forecasts draws a clear distinction between 'stable' and 'dynamic' local areas; following findings from demographic research (which draws the same distinction) – see, for example, Tayman et al (2008). Basically, the predication intervals associated with traffic forecasts are likely to be larger in areas that are characterised by rapid change (significant migration, a highly mobile populace, intense land use or network development). The resulting prediction intervals are presented in Table A1.

Table A1: Empirically-Derived Prediction Intervals (from Bain, 2011)

Area 'Type'	Formula	Prediction Intervals		
		Year 1	Year 10	Year 25
Stable	±7.5% * √n	±8%	±24%	±38%
Dynamic	±10% * √n	±13%	±38%	±50%

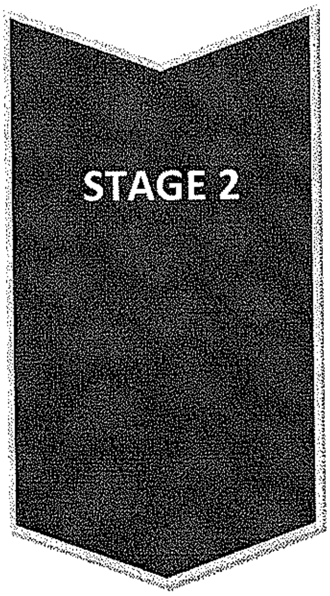
Note: Percentages have been rounded.

To recap, Stage 1 of the post-modelling process framework involves:

- An independent forecast review;
- Adjustment of the central case forecast for any suspected bias;
- Overlay of the prediction intervals suggested by Table A1;
- Adjustment of these predication intervals based on views about future uncertainty in the specific context of the project under consideration.

Stage 2 of the process is summarised below in Figure A5.

Figure A5: Post-Modelling Activities – Stage 2



Risk Workshop
To identify, analyse and discuss (in detail) the key issues/assumptions impacting on the central case forecast and prediction intervals

- Presentations
  - *Traffic consultant(s)*
  - *Economic analysts*
  - *Planning & land use consultants*
  - *Independent Reviewer*
- Explore wide variety of views
- Examine ways in (and the extent to) which central case forecast and initial prediction intervals could be wrong
- Independent Reviewer 'maps' workshop conclusions onto central case forecast and initial prediction intervals

Summary Report to Client

- Client review, comments/feedback
- Make (and document) adjustments

A 'risk workshop' lies at the heart of Stage 2. This workshop is entirely separate from any other presentation of the forecasts (eg. a general presentation of forecast results) – and, as the title suggests, the focus is specifically on <u>risk</u>: risk that central case forecast could be incorrect or that the prediction intervals are inappropriately sized/shaped. In advance of the workshop all of the modelling assumptions are tabulated along with the values employed, the possible range (from which those values are drawn) and – critically – the sources of evidence used in support. A basic assumptions table is shown below:

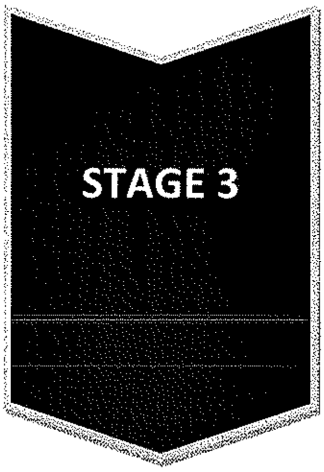
Figure A6: Annotated Assumptions Table

Input Variable	Assumed Value	Possible Range	Empirical Evidence/Sources
X			
Y			
Z			

Workshop participants review the assumptions with the respective expert(s) – making presentations – until a consensus is reached. Considerable emphasis is placed on any evidence that can be used to support the assumptions being made and experts are expected to focus their efforts in this area. Any resulting changes to the original assumption set employed are then 'washed through' the traffic forecasting model and, if required, revised central case predictions (and associated intervals) are derived.

Stage 3 of the process consolidates the findings so far (incorporating any new data/ information) and employs a series of top-down and bottom-up 'sense checks'. Top-down checks take an overview and might use the results from a simple ('naive') model – eg. an extrapolation of historical trends or the outputs from a basic spreadsheet model – to test the reasonableness of the forecasts. Bottom-up checks revisit some of the basic modelling assumptions; perhaps testing the sensitivity – or robustness – of the model outputs (traffic and revenue forecasts) to alternative input variable values.

Figure A7: Post-Modelling Activities – Stage 3



Consolidate & Conclude Evaluation

- Penultimate review of central case forecast and prediction intervals
  - *Top-down and bottom-up sense/logic checks*
  - *New data are incorporated and final changes are adopted*
- Final iteration with client and final documentation

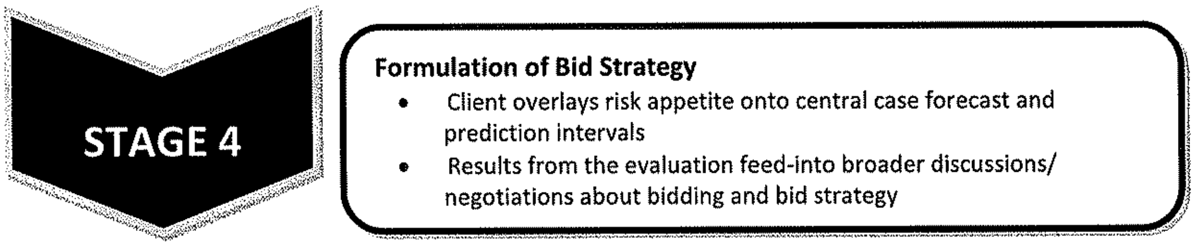
[Client needs to be able to explain the central case forecast, the prediction intervals and how/why they have evolved the way they did]

- Critical for presentation to management, credit committee or investment board
- ...and for institutional learning (building-up forecast-related documentation over time)

Note that at the end of each of the three stages discussed so far, the findings are documented. This documentation is essential. It need not be extensive but should – at a minimum – provide a full 'audit trail'; a record of changes made, key discussions held and reasons for actions. One of the key aims of the 3- (or 4-) stage approach is to promote institutional learning. The private infrastructure investors that the approach was initially developed for are long-term market participants with long-term interests (such as pension funds). They are fully aware that benefits derived from employing the framework will most likely be realised over the long-term; yet fully support introduction and use of the framework today.

As mentioned earlier, the final (optional) stage – Stage 4 – has limited applicability for public sector agencies. At this Stage, private investors are overlaying their own appetite for risk (usually in the context of portfolio exposure) and using the results from the exercise to feed-into their bid strategy formulation (see Figure A8).

Figure A8: Post-Modelling Activities – Stage 4



Closing Comments

Would adoption of the 4-Stage approach outlined above lead to more accurate traffic and revenue forecasts? At this point there is absolutely no evidence to suggest that it would. However, arguably, the past performance of much traffic forecasting has been so dismal that it might prove difficult to perform any worse. However this misses the point. The fact is that forecasts today already have highly subjective assumptions driving them and are commonly subjected to adjustments based on judgment, knowledge, experience etc. The 4-Stage approach simply provides an auditable framework which makes assumptions, judgments and so forth explicit. In the absence of a framework, actions become forgotten and the opportunities to learn lessons from the past are significantly diminished.

The 4-Stage approach is presented, in full, on the following page.

Figure A9: Post-Modelling Activities – Stages 1 to 4 (source: Bain [unpublished])

Evaluating Risk & Uncertainty in Transport Demand (and Revenue) Forecasts

STAGE 1

Independent Review

- Full review of technical documentation
- First-cut adjustment of central case forecast for bias
- Overlay fan chart (standard prediction intervals)
  - *Is uncertainty going to be greater in the future, less or the same?*
- First-cut adjustment of prediction intervals

Summary Report to Client

- Client review, initial comments/feedback
- Make (and document) early adjustments

STAGE 2

Risk Workshop

To identify, analyse and discuss (in detail) the key issues/assumptions impacting on the central case forecast and prediction intervals

- Presentations
  - *Traffic consultant(s)*
  - *Economic analysts*
  - *Planning & land use consultants*
  - *Independent Reviewer*
- Explore wide variety of views
- Examine ways in (and the extent to) which central case forecast and initial prediction intervals could be wrong
- Independent Reviewer 'maps' workshop conclusions onto central case forecast and initial prediction intervals

Summary Report to Client

- Client review, comments/feedback
- Make (and document) adjustments

STAGE 3

Consolidate & Conclude Evaluation

- Penultimate review of central case forecast and prediction intervals
  - *Top-down and bottom-up sense/logic checks*
  - *New data are incorporated and final changes are adopted*
- Final iteration with client and final documentation

[Client needs to be able to explain the central case forecast, the prediction intervals and how/why they have evolved the way they did]

- Critical for presentation to management, credit committee or investment board
- ...and for institutional learning (building-up forecast-related documentation over time)

STAGE 4

Formulation of Bid Strategy

- Client overlays risk appetite onto central case forecast and prediction intervals
- Results from the evaluation feed-into broader discussions/ negotiations about bidding and bid strategy