

**Review of Department for Transport and Airports Commission Reports  
with respect to Demand Modeling and Passenger Allocation**

Prof. Andreas W. Schäfer  
UCL Energy Institute, UCL  
a.schafer@ucl.ac.uk  
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This report has been produced alongside a review about the ICF London Air Traffic Model Report from August, 2014 (hereafter ICF Review). It focuses on the extent to which key model limitations that were identified in the ICF Review are also true for the DfT aviation model used by the Airports Commission (AC). It therefore reviews the modeling, discussion, and presentation of two key components of the Department for Transport (DfT) aviation model suite, which were adopted and modified by the Airports Commission (AC):

- National Air Passenger Demand Model (NAPDM), which forecasts the number of terminal passengers travelling to, from or through the UK at a national level.
- National Air Passenger Allocation Model (NAPAM), which allocates the unconstrained national passenger demand between the 29 largest UK airports and, as an AC extension, to 4 foreign hubs.

An important part of such modeling work is model validation and testing the model's sensitivity to understand the robustness of the results. Hence, this review also addresses the validation efforts and sensitivity tests. Three reports form the basis of this review.

- UK Aviation Forecasts Report (DfT, 2013)
- Airports Commission Interim Report, Appendix 3 (AC, 2013)
- Airports Commission Strategic Fit Forecasts report (AC, 2014)

*The Starting Point: The DfT Aviation Model*

The scale, capability, and level of detail of the DfT aviation model system is impressive. I am not aware of a Transport Department in any other country having such kind of apparatus available for simulating the impact of policies on the national air transportation system through to 2050. In addition, I found the overall modeling approach to be coherent and the model specifications to follow

good practice. A laudable effort was made by the DfT to seek expert reviews and inputs with respect to the:

- DfT National Air Passenger Allocation Model (NAPAM)
- Market maturity assumptions and other factors affecting air travel demand
- Fuel burn rates by aircraft type
- Time series econometrics underlying the demand model (NAPDM)

A comprehensive documentation of the DfT model suite exists. The main body of the 179-page January 2013 UK Aviation Forecasts report consists of 121 pages. The detailed descriptions of the systems model, input assumptions, and the resulting outputs are complemented with a rich 58-page appendix describing the econometric models underlying the various modules along with higher-resolution results.

**NAPDM.** In addition to GDP, consumption, and fares, the NAPDM takes as variables exchange rates, imports and exports for airfreight, along with a number of dummy variables. The model is estimated for different markets with respect to traveller origin, trip purpose, along others. This segmentation is very useful, as elasticities differ across these segments.

Taking advantage of the time series characteristics of the underlying data, NAPDM is specified as a dynamic model. Presumably in anticipation of some variables having unit root characteristics, an equilibrium correction model (ECM) specification was chosen. Page 128 of the UK Aviation Forecasts Report provides the parameter estimates of the ECM. A critical parameter to examine is the lagged traffic term ( $I.Intra$ ). Its value must satisfy  $-1 < I.Intra < 1$  for the variables to be cointegrated. This condition is satisfied for 15 out of 19 segments, except for FBW (Foreign resident, business, Western Europe), FBO (Foreign resident, business, OECD), FLN (Foreign resident, leisure, Newly Industrialised Countries), and I to I (International-international interliner [non-UK transfer]).

Although these four market segments account for a modest 16% of the 2008 passenger traffic (DfT, 2013:Table 25), the I to I traffic alone accounts for 10% of the 2008 passenger traffic alone and is critical to the analysis of hub competition with those outside the UK.

*For these four segments  $I.Intra$  is smaller than -1 (corresponding to a negative autoregressive term in the corresponding ADL model), which implies that the ECM approach is inappropriate, at least with the specification used. However, the AC carried out extensive sensitivity tests in AC(2014:181-191), in which airport capacity extension needs are investigated for a case with zero I to I passengers. The AC might consider adding a footnote mentioning this shortcoming inherited from the NAPDM model estimation.*

**NAPAM.** An in-depth review was produced in 2010 and several of the recommendations were adopted by the DfT (DfT, 2013, page 33). To enable

coherent estimates of the passenger choice among UK and non-UK hubs, the Passenger Airport Choice Model within NAPAM would need to be expanded, which was done by the AC and is discussed below.

Another NAPAM module, the Air Traffic Movements Model (ATM) model translates passenger flows into ATMs. The use of a congestion premium for a scarce airport resource is a plausible way of modeling the demand response (reallocation of passengers to unconstrained airports and loss in travel demand) and supply response (via enhanced use of larger aircraft) to binding airport capacity constraints.

**Validation and Sensitivity Tests.** NAPAM has been validated through comparing the predicted 2011 data (using a year 2008 base) with year 2011 observed passenger flows (i) by major UK airport, (ii) by route, and (iii) air traffic movements at major airports. A 7-page appendix reports validation results in great detail. In addition, a 7-page chapter is dedicated to sensitivity tests, in which the response of NAPDM to different assumptions of economic growth, oil prices, airfares, and market maturity assumptions is tested. However, these sensitivity tests only focus on the aggregate NAPDM results, without further investigating the implications on an airport level. In contrast, the AC has investigated such higher resolution implications in great detail, as described below.

#### *AC Extensions of the DfT Aviation Model*

The core of the AC work is based on extended and improved versions of the NAPDM and NAPAM. As with the DfT report, the AC has produced comprehensive, clear, and transparent studies. Each change to the original DfT model is explained in great detail with respect to rationale, methodology, data, results, and validation. In many cases, the new, updated results are shown next to the original ones from the original DfT model and differences are explained. The validation of and sensitivity tests associated with the model updates are extensive and convincing.

*My only general suggestion is to follow the DfT (2013) report and provide model estimation results, i.e., the coefficient estimates and key estimation statistics. This would make the AC work fully transparent by allowing interested readers to reproduce the AC results.*

**NAPDM.** According to both AC reports, a full update of the econometric models has not been possible in the time available, but a number of countries were re-assigned so that they are now treated as Newly Industrialised Countries (AC, 2015:2.5; AC, 2013:3.19).

*Such country reassignment changes the elasticity estimates of the affected market segments of the respective ECMs, which should be mentioned in the AC reports. A*

thorough approach would require re-estimating the elasticities of the affected market segments. However, the AC has carried out a literature review of post-2007 income and price elasticities and found broad consistency with the used values (AC[2014:12]).

**NAPAM.** To coherently model the passenger choice of I to I travelers in a constrained airport system, the AC has added four non-UK hub choices to the Passenger Allocation Model, i.e., Paris Charles de Gaulle, Amsterdam Schiphol, Frankfurt International and Dubai for I to I travelers and re-estimated the logit model. The new coefficient estimates are reported in Table 2.3 of AC (2014). As with the general suggestion above, this table would enable a better understanding by providing test statistics (likelihood ratio, t-stats,  $R^2$ ) in addition to the number of observations. Moreover, it is not clear why the flight time coefficient is expressed in £ rather than hours. Absent any explanation, the reader could assume that a value of time was assumed because its estimate led to implausible results. To avoid such speculation, the AC could consider providing additional information.

**Validation and Sensitivity Tests.** The AC has extensively validated the extended NAPAM through reproducing the observed passenger flows and related air traffic movements at major UK airports and the four non-UK hubs for the 2011 base year. This validation exercise was repeated for 2013 using the 2011 coefficients, which resulted in only minor differences between model outputs and observations. The validation approach and detailed results are reported in AC(2013:52-56) and AC(2014:204-208).

In contrast to the original DfT model, the AC introduced a Monte Carlo analysis to assign probabilities to the projected passenger flows generated by NAPDM taking into account nine key determinants of the number of terminal passengers, by running more than 2,000 simulations (AC, 2013:36-41). Because of the attribution of probabilities to the range of possible outcomes, this method is superior to the DfT scenario-based analysis.

The AC has also conducted a wide range of detailed sensitivity tests with respect to the inputs of the *assessment of need* scenario, which uses input assumptions from the Office for Budgetary Responsibility, OECD and IMF, along with some judgment-based assumptions, such as those reflecting market maturity. Six sensitivity tests were carried out, which are described in detail in AC(2014:181-203). The sensitivity tests explore differences in the results associated with passenger flows, air traffic movements, and the number of served destinations at the major UK airports, differentiated by short- and long-haul markets, for different runway addition cases.