**Report on:**

# ACCC's Draft FAD for the DTCS (December 2011) and the associated econometric modelling by DAA (November 2011)

**by**

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## 1. Introduction

1.1 The Australian Competition and Consumer Commission ("**ACCC**") has released a *Draft Final Access Determination No. X of 2012 (DTCS)*, ("**Draft FAD"**) for the domestic transmission capacity service ("**DTCS**"). The ACCC proposes that the maximum prices of regulated transmission services will be set by using a regression model to benchmark against current prices for competitive transmission services.

1.2 Two supporting documents were released by the ACCC, namely a report by Data Analysis Australia Pty Ltd entitled *Updated Pricing Model for the Domestic Transmission Capacity Service*, November 2011 ("**DAA Report**") and the ACCC's own *Draft final access determination for the domestic transmission capacity service (DTCS), Explanatory Statement*, December 2011 ("**Explanatory Statement**"). Together, these documents describe the data employed, the modelling methodology and the resulting regression model specified in the Draft FAD.

1.3 The ACCC earlier released a draft of the model proposed for use in the benchmarking activity as *DOMESTIC TRANSMISSION CAPACITY SERVICE (DTCS) Draft regression model for consideration in the public inquiry into a final access determination for the DTCS*, July 2011 ("**Draft Model**"). My analysis of this document and my related advice to Mallesons, acting on behalf of Telstra, is contained in *Observations on: DOMESTIC TRANSMISSION CAPACITY SERVICE (DTCS) Draft regression model for consideration in the public inquiry into a final access determination for the DTCS, Australian Competition and Consumer Commission*, August 2011 ("**Observations on Draft Model**").

1.4 Before seeing the ACCC draft model, I provided a report to Mallesons, acting for Telstra, entitled *Review of Benchmarking Activity Domestic Transmission Capacity Service*, August

2011 ("**Benchmarking Review**"). The purpose of the Benchmarking Review was to provide guidance in relation to the key issues that need to be considered, and accounted for, in undertaking a robust benchmarking activity.

1.5 This report is necessarily high level because I do not have access to the data used in the DAA Report.[1] Therefore I am unable to replicate the regression modelling or to directly test any of the assumptions or decisions made in modelling. Instead I have to rely on the outputs as they appear in that report, which in many cases have been blacked out for confidentiality reasons.

**2. Key Points**

2.1 In my opinion, the regression modelling in the DAA Report is considerably better than in the Draft Model. Improvements have been made in response to my Observations on Draft Model, most notably in these aspects:

(i) better documentation of the data including clearer definitions of some variables;

(ii) more extensive statistical information with which to assess the suitability of estimated models;

(iii) an improved model selection strategy;

(iv) provider-specific quality differences are considered;

(v) the artificial procedure of '+1' for zero distance services is avoided; and

(vi) the prediction implications of the model are considered.

However some important issues remain and some new ones have arisen.

2.2 In this report, subject to the limitations expressed in paragraph 1.5 above, I review aspects of the econometric modelling work described in the DAA Report, in particular:

(i) choices of variables included in the analysis;

(ii) strategies used to determine the model specification; and

(iii) evidence whether the modelling outcomes are robust and fit for purpose.

2.3 I also consider the context and intended use of the econometric regression model, including:

(i) inconsistencies between the DAA Report and the ACCC's Explanatory Statement;

(ii) apparent mistakes in the DAA Report itself; and

(iii) use of predictions from the regression model in regulation.

2.4 The Draft FAD at Table 1 specifies that regulated maximum annual charge for DTCS services on declared routes will be determined from the regression model that is presented in the DAA Report Table 5, with the variable QOS set to 1. For that reason, references to estimation results will relate to Table 5 unless specified otherwise.

[1] In early January 2012, the ACCC released a 10 per cent sub-sample of the data used in the DAA Report. Unfortunately this subset of data is of little use in evaluating the modelling, for the reasons set out in my *Report on Domestic Transmission Capacity Service (DTCS) - release of summary dataset used in preparing the proposed regression model*, January 2012 ("**Report on Summary Dataset**").

## 3. Data issues

3.1 The variable Distance used in the DAA Report is not clearly stated to be radial distance, although radial distance is the measure specified for use in the formula of the Draft FAD. The Explanatory Statement states that providers use different measures of distance. Clarification is needed that the distance variable used in estimating the model is the same radial distance measure as will be employed in the Draft FAD, otherwise the estimation results will not be relevant for the purpose.

3.2 The variable QOS appears to be a characteristic of the provider in the estimation data (DAA Report, pages 2-3, and Table 12) but a characteristic of an individual service in the Explanatory Statement, Chapter 2.4. This apparent contradiction needs to be clarified.

3.3 For the purpose of discussing the econometric results, I assume the DAA Report accurately describes the variable QOS used in estimation. Thus QOS is a condensation of the seven categorical values of Provider into four levels of QOS, with in particular QOS at 1 if and only if Provider is 3. The levels of QOS are interpreted as an ordering, so that 4 is the lowest quality level and 1 is the highest.

3.4 It seems that tail-end-only services (which have zero radial distance) are discarded from the estimation data set (DAA Report, page 3) but are priced in the Draft FAD as if they are regular services with a distance value of 2 km. If this interpretation is correct, the approach removes the concern I expressed in my Observations on Draft Model about distortion of the estimated price-to-distance relationship from making the arbitrary '+1' adjustment of the distance variable.

3.5 The effect of assuming any particular nominal minimum distance in the pricing model can be calculated using the estimates reported in Table 5 of the DAA Report (which are the coefficients adopted in the Draft FAD). The assumption of 2 km adds approximately $0.199\times\ln(2)=0.139$ or 14 per cent to the annual charge that would be predicted for a 1 km distance.[2]

3.6 Little explanation and no justifying analysis or argument is given for the demand factor variables considered in the DAA Report. It is unclear to me how these variables might affect pricing in the DTCS.

3.7 One noticeable feature of the various cross-plots of data in Figures 2 and 3 of the DAA Report is found in the first panel of Figure 2. There it appears that annual charge rises more steeply with distance on regional routes than on either of the other route categories. Therefore it is surprising that interactions between route type and distance are not found to be important in the regression model. From the summary statistics in Table 11 of the same report, I see that regional routes occur frequently in the declared sample, hence the relationship of annual

[2] The percentage difference is reported here as the change in the logarithm multiplied by 100. This form of measuring percentage difference has the advantage that it is symmetric for increases and decreases. It is discussed at length in my Benchmarking Review, paragraph 7.5.

charge to distance will be particularly important in the case of regional routes when predictions are made for declared services.

3.8 The third panel of Figure 2 appears to show that Ethernet services typically have higher annual charges than SDH services for the same route distance. Therefore it is surprising that the network interface variable is not found to be important in a model such as Tables 3 and 5 where distance is also included. The answer might lie in multicollinearity between the network interface variable and other variables. In particular, it can be seen in Table 12 that a large majority of the Ethernet services in the estimation sample are supplied by providers other than the one at QOS 1, suggesting correlation between the network interface and QOS variables. Such correlation would not adversely affect the predictions in the declared sample, provided the same correlation holds in the declared data. However, without analysis of the declared sample being available, it remains unknown whether this latter condition is satisfied.

## 4. Modelling strategy

4.1 The decisions in the DAA Report to logarithm transform the variables Annual charge, Distance and Speed (and also Demand factor 1), are based on the univariate empirical distributions of the respective variables. As noted in my Benchmarking Review (especially paragraphs 7.4, 7.7 and 16.10), an important reason to adopt the logarithm transformation is conformity of the assumed relationships among the variables with what is expected from the engineering and commercial contexts of the data. The coefficients estimated in a regression model specified in logarithm form can be interpreted in terms of proportional or percentage changes. If both variables are in logarithm form, the coefficient is the relative percentage movement or elasticity.

4.2 The automated algorithm for selecting explanatory variables into the regression model (DAA Report, page 7) has the appearance of avoiding judgement factors and basing the model specification on correlations in the data. However, the approach may not be as removed from user judgement as it seems. Restricting the procedure to a threshold of six terms for the sake of interpretability is a judgement call, as is the protocol to retain or discard all related variables as a block.

4.3 The principle of ‘marginality’ (DAA Report, page 7), by which the protocol to retain or discard all related variables as a block is extended to the base cases of an interaction, is also a judgement. However, it might be argued that the principle corresponds to the common practice of including the intercept in a linear model even when it is statistically insignificant.

4.4 The DAA Report adopts the recommendation in my Observations on Draft Model to use the Schwarz BIC criterion for adding variables, rather than statistical significance at 5% as used in the Draft Model. It may be noted that the BIC rule is considerably more stringent. With 4095 observations in the estimation data set, the BIC will improve when a single variable is added only when that variable is significant below 0.004 (compared to 0.05 with 5% significance). The implied joint statistical significance of a block of variables to be added by the BIC criterion is even more extreme. For instance, a four-way categorical block (with three new coefficients) has to be jointly significant below 0.000016 to improve the BIC, although some variables in the block might be individually not significant at that level.

4.5 The additional decision to restrict the model to six terms imposes further stringency on the inclusion of variables. It is not possible to convert that restriction to an equivalent level of significance to compare it directly with the 5% significance criterion, but it does imply that only variables with extreme statistical significance will enter the model on this criterion.[3]

4.6 Model specification is not fully automatic in the DAA Report. The variables Protection and Network interface are reconsidered for inclusion on the grounds they are "known to affect pricing" (DAA Report, page 12). The rule for including them is statistical significance at 5%, a criterion much weaker than improvement of BIC within the threshold of six terms. The Protection variable is selected into the model of Table 5 on those weaker grounds.

4.7 Apart from the matter in the previous paragraph, the DAA Report makes no evaluation of the estimates that are presented in Table 5 (or elsewhere). As discussed in my Observations on Draft Model, valuable information is ignored when automatic rules are used to determine the specification of an econometric model. A model that is not evaluated for its conformity with the engineering and commercial contexts will likely lack robustness when it is applied outside the data set used to estimate it. For this purpose, in section 6 below I examine some of the key coefficient estimates in detail.

**5. Evidence of fragility**

5.1 A comparison of Tables 3 and 5 in the DAA Report suggests that the model specification is somewhat fragile. The only difference between the development strategies leading to these two tables of regression estimates is the use of the Provider and QOS variables as alternatives. As noted in paragraph 3.3 above, the latter is simply an aggregation into four states of the former which has seven states. If the estimation results are robust, they should be little altered by this minor recoding of one variable. However, the models in the two tables are quite different in the following ways:

(i) In Table 3, the variable Provider interacts with ln(Speed) and ln(Distance) while the variable Route does not appear at all, either as a main effect or as any interaction.

(ii) By contrast, in Table 5 the variable QOS interacts with ln(Speed) and the Route variable, but there is no interaction of QOS with ln(Distance).

(iii) The variable Route appears as a main effect in Table 5 (apparently on the principle of marginality), but it plays no role in Table 3.

(iv) In Table 3, there is an interaction of ln(Speed) with ln(Distance), although that interaction is absent from Table 5.

[3] This situation is well illustrated by the protection variable, which is excluded by the automatic modelling procedure, although it is highly significant with a p-value of 0.001 and it improves (i.e. reduces) the BIC between Table 15 and Table 5.

5.2 Despite the detailed differences between the models of Table 3 and 5 described in the previous paragraph, some of the key parameters that determine variation in the annual charge are moderately robust to the different specifications underlying those two tables, at least for some ranges of the variables. So for the example of Provider 3 in Table 3, the elasticity of annual charge with respect to speed is calculated as 0.630 for a 2 Mbps service and 0.585 for a 622 Mbps service, compared with the elasticity of 0.623 for any speed service at QOS 1 in Table 5. Similarly, again for Provider 3 in Table 3, the elasticity of annual charge with respect to distance is calculated as 0.246 for a 0 km distance (priced as 2 km) and 0.186 for a 4,000 km distance, compared with the elasticity of 0.199 for any distance service at QOS 1 in Table 5.

5.3 Similar comparisons to those in the previous paragraph for providers other than Provider 3 will vary more widely between Tables 3 and 5, because of the interaction terms in Table 3 between Provider and both ln(Speed) and ln(Distance).

**6. Interpretations of some estimates in Table 5**

6.1 I noted in my Observations on Draft Model that regression coefficients are frequently able to be interpreted for their meaning in the engineering and commercial contexts that created the data. The DAA Report makes little reference to context and says nothing about the plausibility or otherwise of the coefficient estimates that are reported. The ACCC's Explanatory Statement says more about context, but in general it also avoids specifying expected values of the regression coefficients or other parameters of the relationship between annual charge and its determinants. I offer the following interpretations of the coefficient estimates reported in Table 5.[4]

6.2 (**Speed**) The coefficient on ln(Speed) of 0.623 is the elasticity of annual charge with respect to speed for a service at QOS 1. This elasticity indicates that a 100 per cent increase in speed will increase price by around 62 per cent. As a first approximation, twice the speed allows twice the amount of throughput in the same time, which leads to an expected doubling in value to the user, with a corresponding coefficient value of 1.0. However, it is also likely that price will less than double, for reasons that include more intermittent usage of higher speed services and more expensive connection equipment needed to utilize the higher speed services. While I do not have expert knowledge, the estimated elasticity of 0.623 seems more plausible than the values of 0.34 to 0.47 that were obtained in the ACCC's Draft Model.

6.3 The corresponding elasticities with respect to Speed for services at QOS 2 and 3 are much lower than for QOS 1, [C-i-C]. These differences indicate that providers at lower quality levels receive a smaller premium for higher speed services.

6.4 (**Distance**) The elasticity of annual charge with respect to distance is 0.199 in Table 5 (and constant for all QOS). Thus doubling the distance of a service is predicted to increase its price

[4] I have calculated the regression coefficients in Tables 3 and 5 as the product of the standard error and the t-ratio.

by only about 20 per cent. Again a starting point might be that doubling the distance will double the cost, which would apply for some features of the infrastructure such as cabling and trenching. On the other hand, some costs would be fixed independent of distance, so it is not surprising that the price rise less than proportionally with distance. The estimated elasticity under 0.2 seems low, although again I have not undertaken a detailed assessment of this matter.

6.5 The flat response of annual charge to distance in the model suggests that the model may under-predict the costs of service provision at longer distances. As noted in paragraph 3.7 above, this may be a particular problem on regional routes, where the data plots suggest competitive pricing is more sensitive to distance.

6.6 (**QOS**) The results in Table 5 predict that the lower quality services at QOS 2, 3 and 4 will receive *higher* prices for the same characteristics (of speed, distance, route category and protection) than the highest quality services, particularly at lower speeds and especially for QOS 2 on metro or regional routes, and QOS 4 on regional routes. These results are implausible and suggest that some important factor that represents service quality is missing from, or misrepresented in, the model. On the other hand, this unsatisfactory implication of the model might be resolved by clarifying the definition of QOS and resolving the apparent contradiction between the DAA Report and the Explanatory Statement (as noted in paragraph 3.2 above).

6.7 (**Demand factor**) As noted in paragraph 3.6 above, there is little explanation and no justifying analysis or argument given for the so-called demand factor variables. It is not surprising they are found to be statistically insignificant. On the other hand, a provider should be better able to recover costs on a route with high utilization, which suggests annual charges should be inversely related to utilization.

6.8 (**Route category)** The route category indicators (Intercapital, Metro, Regional) are only included in the model as main effects on the principle of 'marginality', which is invoked because the interaction of route category with QOS is selected into the model by the automated procedure. These variables are individually insignificant even at the 10% level, and therefore must detract from the fit of the model as measured by the criterion of BIC. Ironically, the estimated effects of route category appear in and contribute to the pricing formula of the Draft FAD, while the interaction variables that caused their inclusion do not.

6.9 The Draft FAD is restricted to QOS 1, so the effect of route category in the FAD is just the small direct effects, indicating an 8.1 per cent discount for metro routes and a 5.2 per cent premium for regional routes, both relative to intercapital routes. These estimated differences by route category seem implausibly small and are difficult to explain. I speculate that most of the variation in pricing over different route categories is absorbed by the differences between providers, hence in Table 5 captured by the interactions with QOS. The data summary in the DAA Report Table 12 indicates that the majority of regional services come from the single large provider at QOS 1. Perhaps the smaller providers, while they may sell some services in every route category, do not actively seek business in all route categories. In that case, the few sales made by such providers outside their areas of specialization may not be indicative of competitive pricing. However, they will be influential data points in establishing the interactions between QOS and route types, and hence influential in reducing the direct effects of route type as reported in Table 5.

6.10 Given the observation in paragraph 3.7 above that annual charge appears to rise more rapidly with distance on regional routes, it would be prudent in investigate these interactions further.

6.11 (**Protection**) The estimated premium for a protected service at 7.8 per cent in Table 5 is also small, at about one-half to one-quarter the judgement value of 15-30 per cent proposed in the ACCC's Explanatory Statement, page 24.

**7. Predictive ability of the model**

7.1 The approach of the Draft FAD and the DAA Report is to estimate the model on data for exempt routes, and to employ the estimated model to predict prices on declared routes. As described in my Benchmarking Review, this exercise of prediction outside of the estimation sample establishes a counter-factual, namely the predicted annual charge of a service on a declared route *as if* it were supplied where there is price competition. That calculation assumes the relationship among the variables established by reference to the exempt routes applies equally to the declared routes. That assumption is made without any evidence being provided.

7.2 Of more than 13,000 observations on services available for analysis only the 4,095 exempt services are used to form the model, while the other 9,269 observations on declared services are not used at all. I am surprised that an extended model was not considered, in which the declared services are allowed a price premium to account for the non-competitive market in which they are sold. Chapter 12 of my Benchmarking Review discusses one such approach. This framework could be used to test various assumptions that would help to validate the use of a model estimated on exempt routes to predict prices on declared routes.

7.3 Appendices C and D in the DAA Report are described incorrectly and are significantly misleading as a result. They purport to show the success of the models in Tables 3 and 5 at predicting annual charges for services on *declared* routes (hence prediction outside of the sample used for estimation), when they in fact show within-sample prediction for services on the *exempt* routes. I draw this conclusion on the evidence contained in the various tables where the means of the 'Predicted Annual Charge (Log scale)' and 'Annual Charge (Log scale)' are reported. In almost every case it is the same number in both places, and the few cases where the numbers do differ can be attributed to reporting errors. It is a feature of the least-squares estimation method used in the DAA Report that the mean of the within-sample predictions coincides with the sample mean of the dependent variable. I was mightily impressed with the predictive ability of the model in Table 5 outside of the estimation sample – until I realised the reporting error contained in Appendix D.

7.4 The within-sample prediction of pricing on exempt routes appears in Appendix D of the DAA Report to be quite good. Nevertheless, there is considerable uncertainty in the prediction of any individual observed annual charge. As shown in Table 9 of that report, a confidence interval designed to capture 90 per cent of individual prices has to range up and down by a factor of 73 per cent on the log scale. In the traditional way of calculating percentage movements, the range in dollars extends from of 48 per cent of the predicted median price at the low end up to 207 per cent of the predicted median price at the high end.

7.5 Standard confidence intervals methods allow for the variability due to the intrinsic error term in the model, and for the additional variability arising from the need to estimate the regression coefficients, but they otherwise assume that the model structure is fixed and known. It is difficult to quantify the effect of model uncertainty, except by complex analytical methods that require further modelling assumptions. However, the analysis of sections 5 and 6 above indicates that the model structure in this application is considerably uncertain. If that source of potential variability were to be taken into account, it would widen the range of values to be predicted with any stated degree of confidence. The confidence intervals in the DAA Report are therefore too narrow to convey the degree of uncertainty in making the predictions, although the extent of such understatement is not known.

**8. Use in regulation**

8.1 Clause 1.4 of the Draft FAD places limits on the use of the regression model in price regulation, to speed in the range 2 to 622 Mbps and distance in the range 0 to 4000 km. These seem sensible limits, given the ranges of the variables used in estimation and the fact that prediction becomes more uncertain the further the prediction is made from the average values of the variables.

8.2 Although it does not state so, the Draft FAD uses the prediction of the *expected* or *mean* annual charge from the regression model as the benchmark. That approach is implied by its adoption of the adjusted prediction formula from the DAA Report, Equations 3 and 4, of which it is noted:

> "*The adjustment is relatively small (about 10%) and is appropriate if it is considered that the mean of the distribution is most relevant. If, for example, the median was considered more relevant then the correction should not be applied*." (DAA Report, page 17).

8.3 If the requirement was to benchmark the expected or mean of the price distribution, then the approach adopted would be correct. However, the benchmark is used in the Draft FAD to establish the *maximum* allowable price for given values of the pricing variables (speed, distance, route category, protection). There are no statistical grounds known to me that suggest the mean of the distribution is the correct or natural benchmark to use in setting a maximum.

8.4 Similarly, the median of the distribution has no particular standing for this purpose. By definition, under the assumptions of the model, half of the prices established in the competitive marketplace of the exempt routes will exceed the predicted median. By virtue of the skewed distribution of prices, the proportion of values that exceed the predicted mean will be less than half. However, it will still be quite large: in a log-normal variable with standard deviation parameter of 0.441 (as in the fitted model), about 41 per cent of the observations will exceed the mean.

8.5 An alternative approach that seems more natural is to set the maximum regulated price near the top of the range of expected competitive prices, after cutting off some extreme values as unrepresentative. That approach suggests using a high percentile of the distribution instead of the mean (and certainly not the median, which is the 50$^{th}$ percentile). A judgement would have to be made on the appropriate percentile to use, although that approach would be more transparent than defaulting to the mean, which has no rationale. A statistician might suggest the 80$^{th}$ or 90$^{th}$ percentile of the distribution as indicating the upper extreme of 'likely' values. An alternative method with excellent scientific credentials would be to place the question in a framework of decision-making under uncertainty, by weighing the relative risks of setting the maximum price too low or too high. I observe that the New Zealand Commerce Commission has repeatedly arrived at the 75$^{th}$ percentile in this way.[5]

8.6 The DAA Report establishes that using the mean of the log-normal distribution of predicted price increases the benchmark annual charge by about 10 per cent over the median. From the upper limit on the 80% prediction confidence interval in Table 9 in the DAA Report, it can be seen that the 90$^{th}$ percentile of the distribution is about 76 per cent higher than the median price. Using a similar calculation, the 75$^{th}$ percentile is found to be about 35 per cent more than the median price.

8.7 Figure 1 shows the log-normal prediction distribution with price calibrated along the horizontal axis as multiples of the median of the prediction distribution. The median predicted price is represented by the value 1.0 on this scale. The median and hence the mean of the underlying normally distributed variable is therefore 0 and its standard deviation is the equation standard error of 0.441 from the DAA Report Table 5. The vertical scale represents probability density, which is more readily interpreted by recognising that the area under the curve between two points on the horizontal axis is the probability of a price outcome in that range. The various quantities mentioned in paragraphs 8.4-8.6 can be seen on this diagram. Most of these are obvious from the figure, except perhaps the comment in paragraph 8.4 that 41 per cent of observations will exceed the mean, which is represented in the diagram by the proportion of the area under the curve to the right of the mean of the distribution.

8.8 Figure 1 can be used to set the benchmark price. First the median predicted price in dollars is obtained by applying the reverse logarithm (exponential) transformation to the prediction of

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[5] For example, see NZ MTAS, paragraphs 269 (page 59) and 316 (pages 67-68) or NZ Sub-loop, paragraph 402 (page 82).

log-price from the regression model. Then that median predicted price is multiplied by the factor that corresponds to the appropriate benchmark. Using the 75th percentile as suggested in paragraph 8.5 above will set the benchmark price at 1.35 times the median prediction.

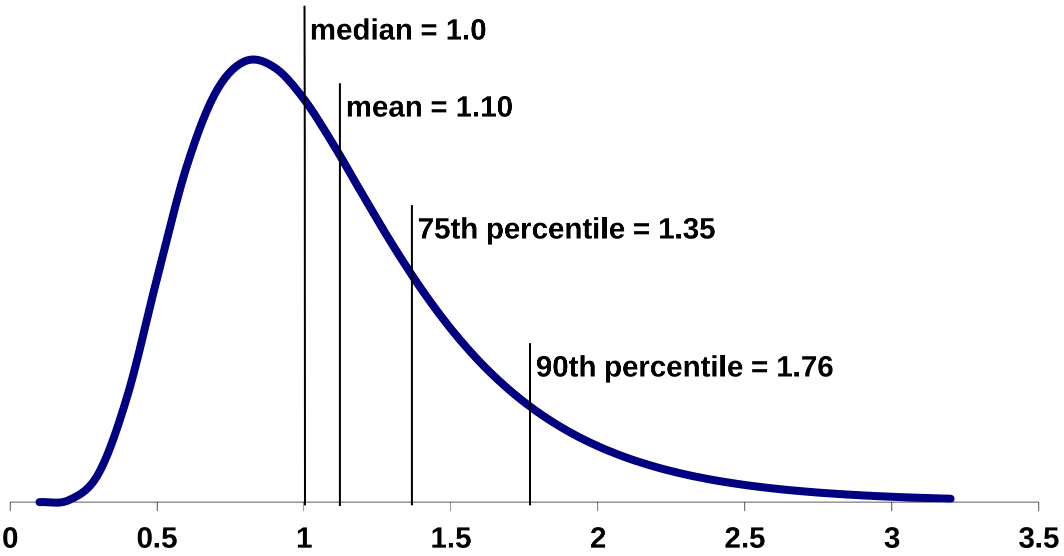


**Figure 1. Log-normal prediction distribution with the median calibrated to 1.0.**

**Documents Consulted**

Australian Competition and Consumer Commission. *Draft Final Access Determination No. X of 2012 (DTCS)* ("**Draft FAD**")

Australian Competition and Consumer Commission. *Draft final access determination for the domestic transmission capacity service (DTCS), Explanatory Statement,* December 2011 ("**Explanatory Statement**")

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