NERA
Economic Consulting

6th May 2008

# Comments on the Deloitte paper on "The Efficiency of BT's Network Operations"

## Stochastic Frontier Models

1. ***Data issues***. There are differences in the way in which both costs and some of the output variables are calculated. The major difference with respect to costs arises because Deloitte have used a rate of return on capital of 10.44%, based upon the weighted average for OpenReach and BT Wholesale. NERA, however, has used a rate of return of 11.4% corresponding to the regulated rate of return for BT Wholesale, which we consider to be a more reasonable representation of the rate of return that applied over the period used for the analysis. Inevitably, this difference means that NERA's base estimates of the costs for all companies are higher than those generated by Deloitte's approach. We address this issue in more detail below.

2. Other differences arise from the way in which the FCC data has been processed, particularly with respect to aberrant data. We have constructed a new set of network costs (different from those used in our OpenReach report) to exclude payphones, which are not included in Deloitte's cost estimates either for the LECs or BT.[1] Detailed investigations show that NERA's and Deloitte's estimates of operating costs are identical after excluding payphones. There are, however, differences in estimates of depreciation and the gross/net replacement cost of capital. They are not large – generally less than 2% of total cost – but in most cases NERA's estimates are lower than the equivalent Deloitte figures. There appears to be a particular problem in the Deloitte data for many LECs in 1996, but we have not identified why this has arisen.

3. There are also minor differences in some of the independent variables – leased lines, switched minutes and total sheath – arising from the way in which the FCC data has been processed. We have tested whether these differences have a significant impact on the econometric modelling. The differences in the log-likelihood values from use of the NERA and Deloitte variants are small, but they tend to favour the NERA variants. The Deloitte total sheath yields a slightly higher value for the log-likelihood, but in this case we are unable to reconcile Deloitte's figures with the FCC data. Hence, we have continued to use our values for the independent variables.

4. Deloitte have used a slightly different approach for population density. In NERA's studies this has always been constant over time and is equal to the population density of the relevant state in the 2000 Census. This implies that population density is a fixed effect over time. There is no assumption that a LEC's costs will alter purely as a consequence of the impact of population growth over time on population density. Deloitte have used a time-varying value for population density, based upon the mid-year population of the relevant state in each year. We have tested these alternative specifications and have concluded that treating population density as a fixed effect is significantly better - LL=793.66 vs LL= 788.46 – so we have not adopted the Deloitte specification of population density.

---

[1] This is done so that we can make direct comparisons between the NERA and Deloitte analyses. The removal of payphones reduces LEC costs by less than 0.5%.

5. Finally, Deloitte have excluded data for two companies that were included in NERA's OpenReach report – Verizon-Washington DC (CDDC) and Southern New England Telephone (SNCT). These LECs serve Washington DC and Connecticut. In the case of CDDC the issue is whether a company that serves a single city that is the Federal capital and is only a small part of the larger metropolitan area is so atypical that it ought to be excluded. Since in practice CDDC operates as a subsidiary of the former Bell Atlantic companies that serve Maryland and Virginia, we believe that it is little different from former GTE subsidiaries operating in small sub-regions of many states. Consequently it should not be excluded. In the case of SNCT, the problem is erratic data due to obvious but uncorrected filing errors for the years 1996-98. We have corrected the most obvious of these errors and retained the company in our dataset.[2] However, for the purpose of direct comparisons between the Deloitte and NERA analyses we have dropped these two LECs.

6. ***Structural breaks***. Deloitte have adopted a specification with two structural breaks, so that the full period 1996-2006 is broken into three sub-periods 1996-98, 1999-2003 and 2003-06. There is no difference between NERA and Deloitte with respect to the existence of a structural break between 1998 and 1999. That has been documented in NERA's previous work and is supported by work undertaken in preparing the OpenReach report. As a consequence, NERA decided to restrict the data period used in the OpenReach report to the period 1999-2006, which provides a reasonable panel of 8 years of data per LEC.

7. We are more sceptical about the value of introducing an additional structural break after 2003. Our scepticism is prompted by reservations about the predictive or analytical value of any econometric model that has to allow for three separate sub-periods in a total period of 11 years. This suggests a worrying lack of stability in the basic model.

8. Deloitte point to an apparent step change in the number of leased lines after 2003. Again, this is correct for some LECs but not all. In our OpenReach report we highlighted the "Verizon anomaly" by which the numbers of special access lines reported by certain Verizon companies (but not former GTE or Contel companies) increased very dramatically in either 2004 or 2005. However, it is worth pointing out that our attempts to capture the influence of this apparent change in reporting procedures did not yield coefficients on the Verizon dummy associated with the number of leased lines that were statistically significant.

9. In any case there is something else going on. For almost all LECs the numbers of switched lines in service peaked in 2000 or 2001 and have been falling steadily since the early part the current decade. In many cases the number of switched lines in 2006 was more than 25% below the number at the peak. Thus, any satisfactory specification needs to take account of the structural shift from switched lines to special access lines that has occurred and seems to be continuing. This has not happened to any significant degree for BT but the data suggests that the number of BT's switched lines may be at or close to a peak and can be expected to fall in future.

---

[2] In our OpenReach study we used data for the period 1999-2006, so that the data errors for SNCT were not a matter of concern in that context.

10. For this reason NERA adopted an alternative specification, which we discussed in our report on Openreach's efficiency. This treats that part of the infrastructure that was installed to meet the peak number of switched lines, but which is no longer required, as stranded assets and allows for a corresponding impact on costs per switched line. This specification produces an improvement in the log-likelihood of the econometric model – but using only one additional variable - that is very similar to the increase obtained by Deloitte by introducing a second structural break (see their Appendix A2). We believe that this is a better way of capturing the structural changes that are affecting the operations of the US LECs as it is involves the use of a stranded asset variable, which is based on a hypothesis of what has affected costs, rather than a set of dummy variables.

11. ***BT's efficiency relative to the decile***. The Deloitte paper concludes that BT's network operation is on or very close to the top decile in terms of its efficiency relative to the US LECs. This is consistent with our finding in the OpenReach study, in which we found that BT Network was about 3-4% more efficient than the decile.

12. We have confirmed this result with both (a) the updated dataset used for the present comparison, and (b) the costs used in the Deloitte study. Indeed, the results from the stranded assets model, which is our preferred specification, consistently suggest that BT Network is 2.5% to 5.5% more efficient than the decile, with relatively small differences between the alternative datasets.

13. Further, we have checked whether this conclusion is sensitive to the value of the cost of capital used in calculating the costs. For this purpose we have estimated the stochastic frontier models using (a) NERA costs calculated with a cost of capital of 10.44%, and (b) Deloitte costs calculated with a cost of capital of 11.4%. Neither of these modifications to the cost of capital leads to a change of more than +/- 0.1% in the efficiency of BT Network relative to the decile, so that we can be confident that the conclusions about BT's comparative efficiency are robust with respect to alternative values of the cost of capital.

14. We believe that the consistency of the results obtained from the Deloitte and the NERA studies suggests that the general conclusion is robust. In summary, BT's network operations fall on or in the top decile in terms of their efficiency relative to US LECs.

15. ***Cost trends over time***. An important aspect of the stochastic frontier models concerns the rate at which costs are rising or falling over time. All of the variables are measured in terms of nominal values, so that the coefficient on the time variable in the models give us the underlying rate of change of costs, controlling for other factors, in dollar terms. Over the time period examined the general rate of inflation in the US – measured by the GDP deflator – was on average 2.2% per year.

16. In the analysis based upon NERA's costs the coefficient on the time variable is -0.8% using data for the full period 1996-2006 but with a separate coefficient for the years 1996-98 of -3.1%. This implies that the rate of decline in the real level of efficient costs has changed significantly from the 1990s to the current decade. Whereas in the 1990s one can reasonably conclude that costs (at constant volumes) were falling in real terms by about 5% per year, now costs are falling in real terms by 2.5-3% per year. This conclusion is supported by the results of estimating the same model using

data for 1999-2006, which yields a coefficient of -0.3% on the time variable (i.e. a real reduction of about 2.5% per year).

17. The results for Deloitte's cost estimates are somewhat ambiguous when data for 1996-2006 is analysed, but we believe that this is a consequence of problems highlighted above in their estimates of costs for 1996 in particular and for 1996-98 more generally. When the analysis is restricted to the period 1999-2006, then the Deloitte costs generate a coefficient of -1.0% on the time variable (equivalent to a real reduction of over 3% per year) – slightly higher than for the NERA costs, but still much less than for the 1990s.

18. Our conclusion is that the stochastic frontier analysis suggests that the rate of productivity growth has slowed substantially in the current decade relative to the rates that were observed in the 1990s.

19. It is worth pointing out that the model specification makes a significant difference to the estimated rate of decline of efficient costs. If the stranded assets variable is omitted from the NERA analysis for 1996-2006, the coefficient on the time variable rises from -0.8% to +0.2%, suggests a rate of productivity improvement of about 2% per year rather than nearly 3% per year. This 1% difference in the annual rate of productivity growth is the result of the structural change that has left substantial stranded assets in the switched networks operated by the US LECs.

## Measurement of Growth in Total Factor Productivity

20. The method adopted by Deloitte for the purpose of assessing growth in total factor productivity for the US LECs is conventional. As their paper explains, it is standard practice to construct a Tornqvist index of output that aggregates over multiple outputs. Similarly, the methods used to measure inputs of materials, labour and capital are also conventional. We have not attempted to cross check the reliability of the data that has been supplied to us by Deloitte, but we have no reason to doubt that it is accurate. In preparing these comments we have concentrated on issues of specification and econometric analysis of the data.

21. However, there is one point that may require clarification. This concerns the measurement of capital inputs. On page 22 the payments to capital as used in equation (14) are said to be depreciation. Clearly this is a mistake, since the total cost of capital inputs is both depreciation (capital consumption) and the opportunity cost of employing the capital. Further, there appears to be a typographical error in the specification of equation (13), since as written it does not correctly deflate current investment to constant prices. We have assumed that these errors have not been carried over into the calculation of the capital inputs for the econometric analysis.

22. ***Trends over time***. In order to understand the forces that have been driving trends in total factor productivity for US telecoms networks it is important to look at the raw data. Table 1 provides summary statistics on year-to-year growth rates for the Tornqvist index of output as well as inputs of staff and capital for the 26 companies covered by the Deloitte study - some of them parent companies like Bell South rather than the state operating companies. With respect to output growth there is a very clear pattern by which output grew rapidly from 1996 to 2000, reached a peak in 2001 and has been declining since then.

**Table 1**
**Distribution of year-to-year growth for US LECs**

| Year | Distribution of year-to-year growth across companies | | | |
|---|---|---|---|---|
| | Mean | SD | Min | Max |
| **Output index** | | | | |
| 1997 | 8.70% | 42.49% | -36.76% | 208.92% |
| 1998 | 7.13% | 12.77% | -4.74% | 61.35% |
| 1999 | 7.68% | 9.02% | -6.86% | 33.66% |
| 2000 | 6.25% | 18.08% | -15.65% | 85.17% |
| 2001 | 1.25% | 11.10% | -16.12% | 39.84% |
| 2002 | -4.23% | 11.32% | -28.52% | 31.93% |
| 2003 | -2.77% | 10.65% | -23.93% | 31.84% |
| 2004 | -8.90% | 16.33% | -56.00% | 7.78% |
| 2005 | 2.86% | 9.57% | -13.91% | 22.10% |
| 2006 | -7.56% | 6.96% | -24.69% | 7.97% |
| **Staff inputs** | | | | |
| 1997 | 6.81% | 11.76% | -32.15% | 27.73% |
| 1998 | 3.26% | 10.27% | -18.78% | 26.42% |
| 1999 | 1.33% | 6.50% | -5.93% | 25.59% |
| 2000 | 1.09% | 9.30% | -20.33% | 18.48% |
| 2001 | 2.19% | 12.98% | -19.31% | 36.20% |
| 2002 | 4.06% | 9.49% | -20.72% | 18.39% |
| 2003 | 6.79% | 18.67% | -16.93% | 47.15% |
| 2004 | 0.90% | 11.46% | -10.22% | 31.57% |
| 2005 | 0.96% | 10.56% | -11.02% | 24.77% |
| 2006 | 1.07% | 9.01% | -10.92% | 19.50% |
| **Capital inputs** | | | | |
| 1997 | 0.54% | 6.07% | -27.12% | 5.56% |
| 1998 | 1.71% | 1.92% | -2.45% | 6.01% |
| 1999 | 0.01% | 2.72% | -3.76% | 10.66% |
| 2000 | 1.56% | 2.75% | -5.34% | 7.31% |
| 2001 | 1.50% | 3.02% | -6.23% | 6.75% |
| 2002 | 0.84% | 29.49% | -10.50% | 144.97% |
| 2003 | -3.95% | 3.05% | -12.35% | 1.59% |
| 2004 | -10.04% | 3.17% | -17.38% | -4.55% |
| 2005 | -8.66% | 5.27% | -20.75% | 0.17% |
| 2006 | -7.23% | 7.09% | -23.48% | 5.28% |

***Source: NERA calculations based upon Deloitte TFP databases.***

23. This pattern has not been matched by changes in staff and capital inputs. Generally, the number of staff employed by the companies has been falling, but the pattern is erratic and not closely correlated with growth in the output index. With respect to growth in capital inputs, this was substantially less than growth in output during the period 1996-2001. Since 2003 the decline in inputs of capital has generally been larger than the decline in the output index, suggesting that the LECs have responded to structural changes in the demand for switched lines by either not replacing

equipment or retiring it early. Thus, in effect the LECs were benefiting from increasing levels of capital utilisation in the 1990s but have faced the problem of reallocating their capital inputs during the current decade rather than allowing capital utilisation to decline.

24. In these circumstances it is a little odd that Deloitte have not included separate time trends for total factor productivity to take account of the very different circumstances up to and after 2001. The SFA model has established that, at a minimum, there is a structural break in the cost equations after 1998. Alternatively, the simple analysis in Table 1 might lead one to expect different rates of growth in total factor productivity before/after 2001. Using the Deloitte data we have tested the inclusion of two time trends for either (a) 1996-98 and 1999-2006, or (b) 1996-2001 and 2002-2006. No matter what econometric specification is adopted we conclude that alternative (b) – separate time trends for 1996-2001 and 2002-2006 – is clearly superior in statistical terms, so we will concentrate on this specification.

25. ***Econometric specification***. Deloitte have used a simple fixed effects panel specification for the econometric estimation of the rate of growth in total factor productivity. It is far from obvious that this is the most appropriate specification. Normally, one would test this specification at a minimum against a random effects model. But, in addition, there are strong a priori reasons to expect that the errors for each company will be serially correlated because it is costly to adjust immediately to changes in demand. Simple tests confirm a high average value for the serial correlation within each panel (typically > 0.7). Further, since the structural changes noted earlier have affected all LECs, it is likely that there will be cross-sectional correlation of errors as well.

26. Table 2 shows the results obtained for the growth in total factor productivity using different model specifications. The Deloitte estimates correspond to the fixed effects model with a single time trend. Allowing for separate time trends for 1996-2001 and 2002-2006, which is strongly supported by the appropriate statistical tests, generates results that are much closer to those from the SFA analysis. Consistently, the various models with two time trends suggest that TFP growth after 2001 has been close to 2% per year and may have been higher.

**Table 2**
**Estimates of growth in total factor productivity for alternative specifications**

| Model specification | TFP growth rates | | |
|---|---|---|---|
| | 1996-2006 | 1996-2001 | 2002-2006 |
| | (SE) | (SE) | (SE) |
| Fixed effects | 1.14% | | |
| | (0.80%) | | |
| Fixed effects - 2 time trends | | 4.47% | 1.86% |
| | | (1.07%) | (0.86%) |
| Random effects | 1.55% | | |
| | (0.48%) | | |
| Random effects - 2 time trends | | 4.87% | 2.31% |
| | | (0.96%) | (0.49%) |
| Random effects with AR1 errors | | 3.21% | 1.90% |
| | | (0.82%) | (0.58%) |
| Random effects with AR1 errors | | 2.98% | 1.87% |
| (estimated using GEE) | | (0.66%) | (0.57%) |
| Prais-Winsten model with AR1 errors | | 3.12% | 1.97% |
| (correlated panels) | | (1.25%) | (1.00%) |
| GLS model with AR1 errors | | 2.11% | 1.58% |
| (heteroskedastic panels) | | (0.63%) | (0.51%) |
| GLS model with AR1 errors | | 5.04% | 3.27% |
| (correlated panels) | | (1.24%) | (0.98%) |

***Source: NERA calculations based upon Deloitte TFP databases.***

## Conclusions

27. NERA's updated analysis of the stochastic frontier model for US LECs confirms our previous conclusion that BT Network is 2-5% more efficient than the decile. This is broadly consistent with Deloitte's conclusion that BT Network is on the decile. In both cases, the SFA estimates suggest that there is no evidence for building an efficiency catch-up into the price control.

28. NERA's stochastic frontier models suggest that the efficient level of costs (at constant volumes) was falling at 2.5% to 3.0% per year in real terms for the period 1999-2006. There is clear evidence that the rate of TFP growth has fallen in the current decade from the level achieved during the 1990s. This is consistent with the structural change that has been occurring in the composition of demand for fixed line services. Re-analysis of Deloitte's econometric model using a more appropriate specification to estimate growth in TFP for the US LECs indicates that the Deloitte range of 0.5% to 1.0% per year is too low by a considerable margin.

29. Our analysis of Deloitte's TFP database indicates the growth in total factor productivity for network services has been about 2% per year since the early years of the current decade. Thus, in summary we have two estimates of the underlying growth in productivity or decline in efficient costs:

    a. 2.5% to 3.0% per year for 1999-2006 from the SFA analysis; and

    b. ~ 2% per year for 2002-2006 from the TFP analysis.

    These figures are consistent with our view that the underlying growth in productivity has fallen since the beginning of the current decade. A point estimate for recent productivity growth (from the TFP analysis) would be 2% per year. Alternatively, a range that is consistent with the two sources of evidence (SFA and TFP) is 2.0% to 2.5% per year.