## 1. Loop Investment

$r^2 = 0.998$ 380 observations

$$
\begin{aligned}
LOOPINV = \; & \underset{(12.53)}{7.624} \; \underset{(-1.23)}{-0.993} \; BELL \\
& \underset{(20.54)}{+0.918} \; LOOP \; \underset{(-0.86)}{-0.049} \; BELLLOOP \\
& \underset{(-3.53)}{-6.030} \; SPECIAL \; \underset{(1.89)}{+3.616} \; BELLSPECIAL \\
& \underset{(-3.61)}{-6.107} \; AREA \; \underset{(1.94)}{+3.707} \; BELLAREA
\end{aligned}
\qquad (1)
$$

where,

| | | |
|---|---|---|
| *LOOPINV* | = | the natural logarithm of the economic value of loop investment per square mile of serving area;[27] |
| *BELL* | = | 1 for Bell companies, 0 for independents; |
| *LOOP* | = | the natural logarithm of loops per square mile of serving area; |
| *BELLLOOP* | = | LOOP for Bell companies only; |
| *SPECIAL* | = | the special-access control variable (see text);[28] |
| *BELLSPECIAL* | = | SPECIAL for Bell companies only; |
| *AREA* | = | the natural logarithm of square miles of serving area; and |
| *BELLAREA* | = | AREA for Bell companies only. |

The equation indicates partial-scale[29] economies for density of loop investment; *i.e.*, loops per square mile. Scale economies for independent companies are approximately 8 percent; so incremental costs are approximately 92 percent of average costs. Partial-scale economies for Bell

---

[27] We do not have time series data for AREA; so we use the same value for all years. This procedure provides a good approximation to density, since there were relatively few significant changes in sizes of serving area.

[28] We do not have time series data for this variable, so we use the 1993 value for all years.

[29] Strictly speaking, scale economies apply only to total costs and not to individual cost components. As output expands, costs in some categories may increase proportionally more than in others. Indeed, costs in some categories may even decline as output increases. Nevertheless, it is useful to observe partial-scale economies to see how each cost component contributes to overall-scale economies.

companies are approximately 13 percent; so incremental costs are approximately 87 percent of average costs.

The equation suggests that costs of dedicated loops are somewhat lower than costs of switched loops. This effect is larger for independents than for Bell companies.

### 2. Switching Investment

We estimated three equations for switching investment. They correspond to Scenarios (a), (b), and (c), described above.

$r^2 = 0.99$ 380 observations

$$SWINV = \underset{(10.26)}{6.494} \underset{(-1.79)}{-1.445}\ BELL$$

$$\underset{(19.33)}{+0.836}\ COMPa \underset{(1.33)}{+0.071}\ BELLCOMPa \qquad \textbf{(2a)}$$

$$\underset{(-2.56)}{-0.135}\ AREA \underset{(1.39)}{+0.092}\ BELLAREA$$

where,

| | | |
|---|---|---|
| *SWINV* | = | the natural logarithm of the economic value of switching investment per square mile of serving area; |
| *COMPa* | = | a composite output variable equal to 0.75 x LOOP + 0.25 x DEM; and |
| *BELLCOMPa* | = | *COMPa* for Bell companies only. |

$r^2 = 0.99$ 380 observations

$$SWINV = \underset{(9.22)}{6.148} \underset{(-1.65)}{-1.397}\ BELL + \underset{(18.76)}{0.818}\ COMPb \underset{(1.25)}{+0.067}\ BELLCOMPb - \underset{(-2.78)}{0.149}\ AREA \underset{(1.23)}{+0.082}\ BELLAREA \qquad \textbf{(2b)}$$

where,

*COMPb* = a composite output variable equal to 0.50 x LOOP + 0.50 x DEM; and

*BELLCOMPb* = *COMPb* for Bell companies only.

$r^2 = 0.99$ 380 observations

$$SWINV = \underset{(8.40)}{5.943} \underset{(-1.58)}{-1.415}\ BELL + \underset{(17.86)}{0.792}\ COMPc \underset{(1.25)}{+0.068}\ BELLCOMPc - \underset{(-3.09)}{0.171}\ AREA \underset{(1.14)}{+0.078}\ BELLAREA \qquad \textbf{(2c)}$$

where,

*COMPc* = a composite output variable equal to 0.25 x LOOP + 0.75 x DEM; and

*BELLCOMPc* = *COMPc* for Bell companies only.

All three equations indicate substantial partial-scale economies with respect to the composite output variable — especially for independents. Partial-scale economies range (between scenarios) from 16 to 21 percent for independents and from 9 to 14 percent for Bell companies.

### 3. Support Investment

$r^2 = 0.99$ 380 observations

$$SUPPINV = \underset{(1.92)}{2.441} \underset{(-1.74)}{-2.851}\ BELL$$

$$+\underset{(11.83)}{0.751}\ DIRINV \underset{(2.80)}{+0.230}\ BELLDIRINV \qquad (3)$$

$$\underset{(-1.99)}{-0.157}\ AREA \underset{(0.830)}{+0.082}\ BELLAREA$$

where,

| | | |
|---|---|---|
| *SUPPINV* | = | the natural logarithm of economic value of support investment per square mile of serving area; |
| *DIRINV* | = | the natural logarithm of economic value of direct investment per square mile of serving area. Direct investment includes investment in cable and wire, circuit equipment, switching and operator systems; and |
| *BELLDIRINV* | = | *DIRINV* for Bell companies only. |

The equation indicates large partial-scale economies for independents, but virtually no partial-scale economies for Bell companies. To calculate partial-scale economies *with respect to outputs*, we need to combine the results of Eq. (3) with those of Eqs. (1) and (2). That is, we first use Eqs. (1) and (2) to estimate how much direct investment increases in response to an increase in outputs. Then, Eq. (3) is used to estimate the indirect effect on support investment. To the extent that Eqs. (1) and (2) embody partial-scale economies, the partial-scale economies of support investment with respect to output are greater than indicated in Eq. (3). These considerations also apply to the expense equations; *viz.*, Eqs. (4) through (8).

## 4. Cable and Wire Maintenance

$r^2 = 0.99$ 380 observations

$$
\begin{aligned}
CWMAINT = {} & \underset{(2.60)}{2.657} \underset{(-3.86)}{-5.067}\ BELL \\
& \underset{(13.34)}{+0.708}\ CWINV \underset{(4.83)}{+0.332}\ BELLCWINV \\
& \underset{(3.04)}{+5.850}\ SPECIAL \underset{(-2.13)}{-4.616}\ BELLSPECIAL \\
& \underset{(2.90)}{+5.571}\ AREA \underset{(-2.01)}{-4.373}\ BELLAREA
\end{aligned}
\qquad \textbf{(4)}
$$

where,

| | | |
|---|---|---|
| *CWMAINT* | = | the natural logarithm of cable and wire maintenance per square mile of serving area; |
| *CWINV* | = | the natural logarithm of economic value of cable and wire investment per square mile of serving area; and |
| *BELLCWINV* | = | *CWINV* for Bell companies only. |

The equation for cable and wire maintenance differs markedly between independent and Bell companies. For independents, there are substantial and statistically significant partial-scale economies; for Bell companies, there are modest and statistically insignificant partial-scale diseconomies. The difference may be the cost of rearrangements, which become increasingly difficult as urban areas become more congested.

The equation suggests that unswitched loops are more costly to maintain than switched loops. This effect is greater for independents than for Bell companies. The higher maintenance costs of dedicated lines may reflect higher costs for rearrangements. The effect may be smaller for Bell companies because of scale economies in handling rearrangements.

## 5. Circuit-Equipment Maintenance

$r^2 = 0.99$ 380 observations

$$CCTMAINT = \underset{(-0.15)}{-0.155} \; \underset{(-1.13)}{-1.649}\, BELL$$

$$+\underset{(14.05)}{0.818}\, CCTINV \; +\underset{(1.56)}{0.124}\, BELLCCTINV \qquad (5)$$

$$+\underset{(4.20)}{10.162}\, SPECIAL \; \underset{(-3.44)}{-9.406}\, BELLSPECIAL$$

$$+\underset{(4.11)}{9.910}\, AREA \; \underset{(-3.36)}{-9.213}\, BELLAREA$$

where,

| | | |
|---|---|---|
| *CCTMAINT* | = | the natural logarithm of circuit-equipment maintenance per square mile of serving area; |
| *CCTINV* | = | the natural logarithm of economic value of circuit-equipment investment per square mile of serving area; and |
| *BELLCCTINV* | = | *CCTINV* for Bell companies only. |

The equation indicates substantial partial-scale economies for independent companies and moderate partial-scale economies for Bell companies. The difference is not statistically significant.

Similar to Eq. (4), this equation suggests that independent companies have substantially higher maintenance costs for unswitched lines than for switched lines. The effect is statistically significant. The coefficient for Bell companies is small and statistically insignificant. As before, the effect may be attributable to differential costs of rearrangements. The Bell effect may be smaller because of scale economies in handling rearrangements.

### 6. Switching Maintenance

$r^2 = 0.99$ 380 observations

$$SWMAINT = \underset{(1.60)}{1.483} \underset{(-1.64)}{-1.898}\ BELL$$

$$\underset{(15.70)}{+0.781}\ SWINV \underset{(2.83)}{+0.173}\ BELLSWINV \qquad (6)$$

$$\underset{(-2.55)}{-0.156}\ AREA \underset{(0.58)}{+0.044}\ BELLAREA$$

where,

| | | |
|---|---|---|
| *SWMAINT* | = | the natural logarithm of switching maintenance per square mile of serving area; and |
| *BELLSWINV* | = | *SWINV* for Bell companies only. |

The equation for switching maintenance has the same pattern as that for circuit maintenance. There are large partial-scale economies for independent companies and small, statistically insignificant partial economies of scale for Bell companies.

### 7. General Maintenance

$r^2 = 0.99$ 380 observations

$$GENMAINT = \underset{(-3.91)}{-2.979} \underset{(-0.98)}{-0.949}\ BELL$$

$$\underset{(25.52)}{+0.980}\ INV \underset{(2.00)}{+0.097}\ BELLINV \qquad (7)$$

$$\underset{(0.58)}{+0.026}\ AREA \underset{(-0.60)}{-0.034}\ BELLAREA$$

where,

| | | |
|---|---|---|
| *GENMAINT* | = | the natural logarithm of general maintenance expense per square mile of serving area. We define general maintenance as total maintenance less maintenance for cable and wire, circuit equipment, switching, and operator systems; |
| *INV* | = | the natural logarithm of economic value of total investment per square mile of serving area; and |
| *BELLINV* | = | *INV* for Bell companies only. |

The equation indicates modest and statistically insignificant partial economies of scale for independent companies. It indicates moderate and statistically insignificant partial diseconomies of scale for Bell companies.

### 8. Non-Plant-Related Expense

$r^2 = 0.99$ 380 observations

$$NONPLANTEXP = \underset{(-2.08)}{-1.559} \; \underset{(0.69)}{+0.657} \; BELL$$

$$\underset{(25.61)}{+0.967} \; INV \; \underset{(0.11)}{+0.005} \; BELLINV \qquad \textbf{(8)}$$

$$\underset{(-0.23)}{-0.010} \; AREA \; \underset{(-1.14)}{-0.064} \; BELLAREA$$

where,

*NONPLANTEXP* = the natural logarithm of non-plant-related expense per square mile of serving area.

The equation for non-plant-related expenses indicates modest partial economies of scale for both independents and Bell companies. In both cases, scale economies are statistically insignificant.

## VIII. Estimates of Incremental Costs

This section presents our estimates of ELRICs and TELRICs of loops and switching costs. Our estimates are national averages. Average incremental costs of loops and switching ports are weighted by number of loops (of each company); average incremental cost of DEMs is weighted by number of DEMs. These estimates reflect nominal values during 1990 through 1994. We found no significant time trend for nominal incremental costs. (This finding corresponds to a decline of 3

percent per year in *real* incremental costs.) Consequently, the estimates can appropriately be used on a forward-looking basis.[30]

## A. Loops

Table 2 shows our estimates of the ELRIC and TELRIC of loops. They are $20.22 per month and $23.17 per month, respectively. The TELRIC estimate can be compared to the FCC's proxy price of $14.32 per month. Our estimate is 62 percent higher than the FCC proxy.

**Table 2**
**Top-Down Estimates of Cost Elements**
**Loops**

| Output | Cost Category | ELRIC | TELRIC |
|---|---|---|---|
| | | (Dollars per Loop per Month) | |
| Loops | Loop Plant | $9.28 | $10.56 |
| | Support Plant | 2.08 | 2.42 |
| | C&W Maintenance | 2.51 | 2.90 |
| | Circuit Maintenance | 0.22 | 0.26 |
| | General Maintenance | 1.59 | 1.78 |
| | Non-plant-related | 4.54 | 5.25 |
| | **Total** | **$20.22** | **$23.17** |

If our estimates are accurate, the FCC proxy prices, if implemented, would provide an outright subsidy of $8.85 per month per loop to competing local exchange carriers (CLECs). In addition, the rates would allow CLEC customers (who indirectly use LEC facilities) to avoid making any (direct or indirect) contribution to the overhead costs of incumbent LECs. The consequence would be rate increases for remaining customers of incumbent LECs and/or reductions in earnings of incumbent LECs (without any finding by the Commission that current earnings are excessive).

[30] In our sensitivity analysis, we use estimated trends (albeit statistically insignificant) to develop forecasts for 1997-1999.

HAI estimate that loop costs average $13.84 per month. The difference between the HAI estimate and ours is $9.33 per month. This difference consists partly of indirect effects that are not reflected in bottom-up models. In addition, HAI deliberately exclude certain categories of costs (*e.g.*, costs of customer contacts) that, in our view, are essential for conducting business — whether with CLECs or with end users. HAI also use procedures that understate some categories of costs. For example, they apply ratios based on the operations of Ameritech (which has relatively short loops and low costs) to other companies for which those ratios are inapplicable. Part of the difference in estimates is also attributable to HAI's green-field approach. In reality, growth in loops is often accommodated by complex rearrangements of existing loop sections. Such rearrangements allow capacity to be added in increments that are sufficiently large to be cost-effective. This ongoing process, which incurs real costs to meet real growth, is wholly absent from HAI's model. Put another way, HAI's green-field model applies to an imagined idyllic community where telecommunications needs never change. In any event, the Commission should attempt to reconcile the large differences between estimates and form its own judgments regarding the various approaches.

### B. Switching

Incremental switching costs include TS costs (expressed as dollars per DEM) and NTS costs (expressed as dollars per loop per month). These costs vary across Scenarios (a), (b), and (c), described above.

Interconnection charges for switching should recover (in addition to appropriate overhead loadings) both incremental TS and incremental NTS costs of switching. For economic efficiency, the incremental TS costs should be recovered from per-minute charges (or other charges related to quantity of usage); the incremental NTS costs should be recovered from per-loop (per-month) connection charges. Such interconnection charges are often expressed as charges for switching ports.

They should, however, recover *all* incremental NTS switching costs — not just those associated with the port itself. Otherwise, the remaining incremental costs will either not be recovered or be recovered in an inefficient manner.

Tables 3A, 3B, and 3C present our estimates of incremental switching costs for Scenarios (a), (b), and (c), respectively.

**Table 3A**
**Top-Down Estimates of Cost Elements**
**Switching: Scenario (a)**

| Output | Cost Category | ELRIC | TELRIC |
|---|---|---|---|
| | | (Dollars per Loop per Month) | |
| Switching NTS | Switching Plant | $3.49 | $3.91 |
| | Support Plant | 0.64 | 0.72 |
| | Switching Maintenance | 1.09 | 1.27 |
| | General Maintenance | 0.48 | 0.54 |
| | Non-plant-related | 1.38 | 1.55 |
| | **Total** | **$7.08** | **$7.99** |
| | | (Dollars per DEM) | |
| Switching TS | Switching Plant | $0.00078 | $0.00088 |
| | Support Plant | 0.00014 | 0.00016 |
| | Switching Maintenance | 0.00024 | 0.00028 |
| | General Maintenance | 0.00009 | 0.00012 |
| | Non-plant-related | 0.00028 | 0.00035 |
| | **Total** | **$0.00153** | **$0.00179** |

| Table 3B<br>Top-Down Estimates of Cost Elements<br>Switching: Scenario (b) | | | |
|---|---|---|---|
| **Output** | **Cost Category** | **ELRIC** | **TELRIC** |
| | | (Dollars per Loop per Month) | |
| Switching NTS | Switching Plant | $2.27 | $2.61 |
| | Support Plant | 0.42 | 0.48 |
| | Switching Maintenance | 0.71 | 0.83 |
| | General Maintenance | 0.32 | 0.36 |
| | Non-plant-related | 0.90 | 1.03 |
| | **Total** | **$4.62** | **$5.31** |
| | | (Dollars per DEM) | |
| Switching TS | Switching Plant | $0.00153 | $0.00175 |
| | Support Plant | 0.00028 | 0.00032 |
| | Switching Maintenance | 0.00048 | 0.00056 |
| | General Maintenance | 0.00018 | 0.00024 |
| | Non-plant-related | 0.00054 | 0.00069 |
| | **Total** | **$0.00301** | **$0.00356** |

| Table 3C<br>Top-Down Estimates of Cost Elements<br>Switching: Scenario (c) | | | |
|---|---|---|---|
| **Output** | **Cost Category** | **ELRIC** | **TELRIC** |
| | | (Dollars per Loop per Month) | |
| Switching NTS | Switching Plant | $1.10 | $1.30 |
| | Support Plant | 0.20 | 0.24 |
| | Switching Maintenance | 0.34 | 0.41 |
| | General Maintenance | 0.15 | 0.18 |
| | Non-plant-related | 0.43 | 0.51 |
| | **Total** | **$2.22** | **$2.64** |
| | | (Dollars per DEM) | |
| Switching TS | Switching Plant | $0.00223 | $0.00263 |
| | Support Plant | 0.00041 | 0.00048 |
| | Switching Maintenance | 0.00069 | 0.00085 |
| | General Maintenance | 0.00027 | 0.00036 |
| | Non-plant-related | 0.00079 | 0.00104 |
| | **Total** | **$0.00439** | **$0.00536** |

The individual estimates of ELRIC and TELRIC vary considerably across scenarios. That is, the individual estimates are sensitive to the assumptions that underlie Scenarios (a), (b) and (c).

The bottom line, however — *i.e.*, the revenue that would be recovered by pricing switching at incremental cost — is not sensitive to these assumptions. For our sample of 76 companies for 1990 through 1994, pricing switching at TELRIC would yield the following revenues:

**Scenario (a):** $82.8 billion

**Scenario (b):** $82.4 billion

**Scenario (c):** $82.0 billion

These revenues are all within 1 percent of one another.

Our estimates of incremental switching costs apply to the end-office switches and tandem switches that comprise the current network. No NTS costs are associated with tandem switches; so incremental NTS switching costs entirely reflect costs associated with end-office switches. Our estimate of incremental TS switching costs should be interpreted as a weighted average of the incremental TS costs of end-office switches and tandem switches.

Our estimates of incremental NTS costs reflect the costs of connecting the loops and switches that comprise the current network. Those loops are largely voice-grade analog, but digital loops are increasingly used. The NTS switching costs associated with digital connections are significantly less than those associated with analog connections.

### 1. FCC's Proxies

The revenues in the three scenarios can be compared to the revenue that would be raised by pricing switching elements at the FCC's proxy prices. Those prices are $1.10 to $2.00 per loop per month and $0.002 to $0.004 per minute of usage. Applying the upper end of each of these proxies to our sample would yield the following revenues:

**FCC Proxies:** $61.9 billion

The revenues yielded in any of our three scenarios are over 32 percent higher than those yielded by the upper end of the FCC proxies.[31] Hence, in the relevant (bottom-line) sense, our estimates of TELRIC are 32 percent higher than the FCC's proxies.

If our estimates are accurate, the FCC proxy prices, if implemented, would involve a massive subsidy to CLECs. They would afford wholly distorted market incentives and lead to large-scale waste. Indeed, the FCC proxy prices (considering the NTS and TS prices together) are not even in the same range as our cost estimates. In our view, those proxies are based on a monumental under-estimation of incremental switching costs.

Facilities-based CLECs would be likely to use broad-band digital connections. As a result, the incumbent LEC would save substantial NTS switching costs in the long run. The CLEC has no incentive to engage in such cost-saving activity if regulators mandate that analog connections be provided at a price far below cost. For that reason, use of the FCC proxies might discourage efficient facilities-based competition.

### 2. HAI's Cost Estimates

HAI's estimates of incremental switching costs are even lower than the Commission's proxy prices. According to HAI, the TELRIC for switching ports is $1.02 per month and the TELRIC for switching usage is $0.0018 per minute. Applying these estimates as prices in our sample would yield the following revenues:

**HAI:** $28.8 billion

---

[31] Revenues would be even lower to the extent that some DEMs are priced at the even-lower proxy for tandem switching usage.

The revenues yielded in any of our three scenarios are almost three times as high as those yielded by pricing at the HAI estimates.[32] HAI's estimates reflect a green-field network that uses more digital loops, and fewer analog loops, than the real-world network. Needless to say, HAI's estimates of the costs of connecting digital loops should not be used to set the prices of connecting analog loops.

### C. Estimated Scale Economies

The estimates of ELRIC and TELRIC differ primarily because of differential scale economies. Substantial differential scale economies exist for loops and switching. Differential scale economies amount to about 13 percent for loops and range from 11 to 16 percent for switching NTS and from 15 to 18 percent for switching TS in the three scenarios.

Given that there are substantial scale economies, pricing at ELRIC will not suffice to recover the firm's total cost. Prices must be set substantially above ELRIC. The loading for scale economies is in addition to that required to fund subsidies and the need to make up for the failure to recover costs fully in the past.

TELRIC, by definition, reflects only limited scale economies. In particular, TELRIC does not include any scale economies associated with dedicated plant. It includes the entire average cost associated with such plant, because the plant would not be needed if the service were discontinued. By contrast, the ELRIC is substantially less than average cost, because incremental capacity (over and above that required to meet current levels of demand) can be supplied for significantly less than average cost.

---

[32] Revenues would be even lower to the extent that some DEMs are priced at HAI's even lower cost estimate for tandem switching.

# IX. Sensitivity Analysis

This section presents our sensitivity analysis. We explore herein alternative modeling assumptions and observe how they affect our cost estimates.

## A. Capital Valuation Based on Hatfield's Green-field Model

In this sensitivity run, we use low estimates of the economic value of capital — consistent with the Hatfield Model. At the same time, we use high estimates of economic depreciation — consistent with the low estimates of economic value. In Section V, we described and justified our methods for deriving these estimates of economic value and economic depreciation.

**Table 4**
**Top-Down Estimates of Cost Elements**
**Capital Valuation Based on**
**Hatfield's Green-field Model**

| Output | Cost Category | ELRIC | TELRIC |
|---|---|---|---|
| | | (Dollars per Loop per Month) | |
| Loops | Loop Plant | $9.07 | $10.33 |
| | Support Plant | 2.05 | 2.39 |
| | C&W Maintenance | 2.51 | 2.90 |
| | Circuit Maintenance | 0.22 | 0.26 |
| | General Maintenance | 1.59 | 1.78 |
| | Non-plant-related | 4.54 | 5.25 |
| | **Total** | **$19.98** | **$22.91** |
| | | (Dollars per Loop per Month) | |
| Switching NTS | Switching Plant | $3.81 | $4.27 |
| | Support Plant | 0.64 | 0.71 |
| | Switching Maintenance | 1.09 | 1.27 |
| | General Maintenance | 0.48 | 0.54 |
| | Non-plant-related | 1.38 | 1.55 |
| | **Total** | **$7.40** | **$8.34** |
| | | (Dollars per DEM) | |
| Switching TS | Switching Plant | $0.00085 | $0.00096 |
| | Support Plant | 0.00014 | 0.00016 |
| | Switching Maintenance | 0.00024 | 0.00028 |
| | General Maintenance | 0.00007 | 0.00012 |
| | Non-plant-related | 0.00020 | 0.00035 |
| | **Total** | **$0.00150** | **$0.00187** |

This sensitivity analysis yields a surprising result:

- The use of low economic values of capital, together with consistent estimates of economic depreciation, has virtually no effect on estimated incremental costs. The reduction of 37 percent in economic value (implied by the HM) corresponds to a reduction of only 1 percent in TELRIC loops and an increase of about 4 percent for TELRIC switching.

That is, the estimates of incremental costs in Table 4 are approximately the same as the base-case estimates in Tables 2 and 3A.

This finding has important implications for reconciling top-down and bottom-up estimates. It suggests that the low cost estimates of the HM do not derive from low estimates of economic value, *per se*. Rather, they derive from low estimates of economic value, together with wholly inconsistent estimates of economic depreciation.

### B. Return to Capital of 10 Percent per Year

In this sensitivity run, we use an assumed return to capital of 10 percent per year.

**Table 5**
**Top-Down Estimates of Cost Elements**
**Return to Capital of**
**10 Percent per Year**

| Output | Cost Category | ELRIC | TELRIC |
|---|---|---|---|
| | | (Dollars per Loop per Month) | |
| Loops | Loop Plant | $8.96 | $10.20 |
| | Support Plant | 1.99 | 2.32 |
| | C&W Maintenance | 2.51 | 2.90 |
| | Circuit Maintenance | 0.22 | 0.26 |
| | General Maintenance | 1.59 | 1.78 |
| | Non-plant-related | 4.54 | 5.25 |
| | **Total** | **$19.81** | **$22.71** |
| | | (Dollars per Loop per Month) | |
| Switching NTS | Switching Plant | $3.40 | $3.81 |
| | Support Plant | 0.62 | 0.69 |
| | Switching Maintenance | 1.09 | 1.27 |
| | General Maintenance | 0.48 | 0.54 |
| | Non-plant-related | 1.38 | 1.55 |
| | **Total** | **$6.97** | **$7.86** |
| | | (Dollars per DEM) | |
| Switching TS | Switching Plant | $0.00076 | $0.00085 |
| | Support Plant | 0.00014 | 0.00015 |
| | Switching Maintenance | 0.00024 | 0.00028 |
| | General Maintenance | 0.00009 | 0.00012 |
| | Non-plant-related | 0.00028 | 0.00035 |
| | **Total** | **$0.00151** | **$0.00175** |

Comparing Table 5 to Tables 2 and 3A, we see that the lower cost of capital reduces our incremental-cost estimates by about 2 percent. The effect of capital costs is smaller in this sensitivity run than reported in other analyses.[33] One reason is that our top-down analysis is based on (realistic) estimates of economic depreciation that substantially exceed regulatory depreciation. Consequently, return to capital is a relatively smaller component of total capital costs.

[33] For example, *see* Christensen Associates, *Economic Evaluation of Proxy Cost Models for Determining Universal Service Support*, January 9, 1997.

## C. Estimated Time Trends

In this sensitivity run, we use estimated time trends to forecast incremental costs for 1997 to 1999. The time trends were not used in our base case, because the estimated trends in most equations were insignificant. Nevertheless, it is interesting to see how using our best (albeit statistically insignificant) estimates of time trends would affect results.

**Table 6**
**Top-Down Estimates of Cost Elements**
**Estimated Time Trends**

| | | 1997 | | 1998 | | 1999 | |
|---|---|---|---|---|---|---|---|
| **Output** | **Cost Category** | **ELRIC** | **TELRIC** | **ELRIC** | **TELRIC** | **ELRIC** | **TELRIC** |
| | | (Dollars per Loop per Month) | | | | | |
| Loops | Loop Plant | $9.89 | $10.56 | $9.91 | $10.56 | $9.93 | $10.56 |
| | Support Plant | 2.21 | 2.40 | 2.22 | 2.41 | 2.22 | 2.41 |
| | C&W Maint. | 2.43 | 2.80 | 2.38 | 2.78 | 2.33 | 2.75 |
| | Circuit Maint. | 0.22 | 0.24 | 0.21 | 0.24 | 0.21 | 0.24 |
| | General Maint. | 1.66 | 1.76 | 1.66 | 1.75 | 1.67 | 1.75 |
| | Non-plant-related | 4.68 | 5.13 | 4.67 | 5.11 | 4.64 | 5.09 |
| | **Total** | **$21.09** | **$22.89** | **$21.05** | **$22.85** | **$21.00** | **$22.80** |
| | | (Dollars per Loop per Month) | | | | | |
| Switch-ing NTS | Switching Plant | $3.28 | $3.91 | $3.21 | $3.91 | $3.15 | $3.91 |
| | Support Plant | 0.59 | 0.72 | 0.58 | 0.72 | 0.57 | 0.72 |
| | Switching Maint. | 1.21 | 1.37 | 1.22 | 1.39 | 1.22 | 1.40 |
| | General Maint. | 0.44 | 0.53 | 0.43 | 0.53 | 0.43 | 0.52 |
| | Non-plant-related | 1.25 | 1.50 | 1.21 | 1.49 | 1.18 | 1.48 |
| | **Total** | **$6.77** | **$8.03** | **$6.65** | **$8.04** | **$6.55** | **$8.03** |
| | | (Dollars per DEM) | | | | | |
| Switch-ing TS | Switching Plant | $0.00073 | $0.00088 | $0.00072 | $0.00088 | $0.00070 | $0.00088 |
| | Support Plant | 0.00013 | 0.00016 | 0.00013 | 0.00016 | 0.00013 | 0.00016 |
| | Switching Maint. | 0.00027 | 0.00032 | 0.00027 | 0.00033 | 0.00027 | 0.00034 |
| | General Maint. | 0.00009 | 0.00012 | 0.00009 | 0.00012 | 0.00009 | 0.00012 |
| | Non-plant-related | 0.00025 | 0.00033 | 0.00025 | 0.00033 | 0.00023 | 0.00033 |
| | **Total** | **$0.00147** | **$0.00181** | **$0.00146** | **$0.00182** | **$0.00142** | **$0.00183** |

We previously noted that estimated time trends were positive in some equations and negative in others. Comparing TELRICs in Table 6 to Tables 2 and 3A, we see that the overall time trend is slightly negative for loops and slightly positive for switching. The TELRIC forecasts for 1997 to 1999 are all within 2 percent of those estimated without a time trend.

## D. Holding-Company Variable

In our base case, we estimated separate models for Bell and independent telephone companies. In this sensitivity run, we use a different model for distinguishing among telephone companies. Instead of the Bell variables in Equations (1) through (8), we use variables that reflect the size of the holding company. These variables are all defined as number of holding-company access lines multiplied by the explanatory variable [analogous to the way that the Bell variables are defined in Equations (1) through (8)].

**Table 7**
**Top-Down Estimates of Cost Elements**
**Holding-Company Variable**

| Output | Cost Category | ELRIC | TELRIC |
|---|---|---|---|
| | | (Dollars per Loop per Month) | |
| Loops | Loop Plant | $9.37 | $10.56 |
| | Support Plant | 2.00 | 2.34 |
| | C&W Maintenance | 2.21 | 2.78 |
| | Circuit Maintenance | 0.23 | 0.26 |
| | General Maintenance | 1.49 | 1.70 |
| | Non-plant-related | 4.65 | 5.29 |
| | **Total** | **$19.95** | **$22.93** |
| | | (Dollars per Loop per Month) | |
| Switching NTS | Switching Plant | $3.29 | $3.91 |
| | Support Plant | 0.57 | 0.69 |
| | Switching Maintenance | 0.98 | 1.24 |
| | General Maintenance | 0.42 | 0.50 |
| | Non-plant-related | 1.31 | 1.57 |
| | **Total** | **$6.57** | **$7.91** |
| | | (Dollars per DEM) | |
| Switching TS | Switching Plant | $0.00074 | $0.00088 |
| | Support Plant | 0.00013 | 0.00015 |
| | Switching Maintenance | 0.00022 | 0.00027 |
| | General Maintenance | 0.00009 | 0.00011 |
| | Non-plant-related | 0.00026 | 0.00035 |
| | **Total** | **$0.00144** | **$0.00176** |

Using the holding-company variables instead of Bell variables has little effect on our results. The TELRIC estimates are 0 to 1 percent lower in Table 7 than in the base case (though effects on ELRIC are larger).

### E. Urban Variable

In this sensitivity run, we use another alternative approach to model differences among telephone companies. Instead of the Bell variables in Equations (1) through (8), we use variables that specify whether the company serves major urban areas within the state. Our list of companies that meet this criterion is given in Section III.

**Table 8**
**Top-Down Estimates of Cost Elements**
**Urban Variable**

| Output | Cost Category | ELRIC | TELRIC |
|---|---|---|---|
| | | (Dollars per Loop per Month) | |
| Loops | Loop Plant | $9.44 | $10.56 |
| | Support Plant | 2.05 | 2.36 |
| | C&W Maintenance | 2.47 | 2.87 |
| | Circuit Maintenance | 0.22 | 0.25 |
| | General Maintenance | 1.61 | 1.77 |
| | Non-plant-related | 4.60 | 5.22 |
| | **Total** | **$20.39** | **$23.03** |
| | | (Dollars per Loop per Month) | |
| Switching NTS | Switching Plant | $3.48 | $3.91 |
| | Support Plant | 0.62 | 0.69 |
| | Switching Maintenance | 1.08 | 1.26 |
| | General Maintenance | 0.48 | 0.53 |
| | Non-plant-related | 1.37 | 1.54 |
| | **Total** | **$7.03** | **$7.93** |
| | | (Dollars per DEM) | |
| Switching TS | Switching Plant | $0.00078 | $0.00088 |
| | Support Plant | 0.00014 | 0.00015 |
| | Switching Maintenance | 0.00024 | 0.00027 |
| | General Maintenance | 0.00009 | 0.00012 |
| | Non-plant-related | 0.00027 | 0.00034 |
| | **Total** | **$0.00152** | **$0.00176** |

Use of the urban variable makes virtually no difference. The estimated incremental costs in Table 8 are virtually the same as in Tables 2 and 3A.

## F. Alternative Model for Non-Plant-Related Expense

In this run, we model non-plant-related expense as a function of plant-specific expense rather than total investment. Plant-specific expense includes maintenance of specific plant (cable and wire, circuit equipment, switching, and operator systems) and support plant. The estimated equation is as follows:

$$r^2 = 0.99 \qquad 380 \text{ observations}$$

$$\begin{aligned} NONPLANTEXP = {} & \underset{(0.57)}{0.355} + \underset{(3.18)}{2.474}\, BELL \\ & + \underset{(27.92)}{0.966}\, PLANTEXP - \underset{(-2.96)}{0.124}\, BELLPLANTEXP \\ & - \underset{(-0.27)}{0.011}\, AREA - \underset{(-2.34)}{0.120}\, BELLAREA \end{aligned} \tag{9}$$

where,

| | | |
|---|---|---|
| *PLANTEXP* | = | the natural logarithm of plant-specific expense per square mile of serving area; and |
| *BELLPLANTEXP* | = | PLANTEXP for Bell companies only. |

For independents, the estimated degree of partial-scale economies in Eq. (9) is virtually identical to Eq. (8). Consequently, our estimates of incremental costs of independents are virtually unchanged (from Tables 2 and 3A).

The Bell coefficient, however, differs considerably between Eqs. (8) and (9). In Eq. (8), that coefficient is close to zero, indicating that Bell companies have the same modest partial-scale economies as independents. In contrast, Eq. (9) indicates that Bell companies have partial-scale economies that are 12 percent higher than independents. Thus, for Bell companies, the contribution

of non-plant-related expense to ELRIC is approximately 12 percent lower in Eq. (9) than in Eq. (8). The effect is somewhat smaller for TELRIC, because TELRIC embodies limited-scale economies. As a result of the change in Bell scale economies, our estimates of ELRIC decline by about 2 percent (below those shown in Tables 2 and 3A). The changes in TELRIC are somewhat smaller.

### G. Summary of Sensitivity Analysis

The sensitivity analysis indicates that our TELRIC results are robust with respect to alternative estimates of the economic value of capital, return to capital, time trends, and alternative ways to model differences among telephone companies. Those considerations do not appear to explain any appreciable part of the difference between our top-down model and bottom-up models, such as the HM.

The sensitivity run involving low economic values of capital (consistent with the HM) is especially important. It suggests that low estimates of the economic value of capital do not yield low estimates of incremental costs — so long as consistent estimates of economic depreciation are also used. The low estimates of the HM are attributable, in part, to their inconsistent use of low estimates of economic values and regulatory depreciation (as a proxy for economic depreciation).

## X. Absence of Rationale for Low Estimates of TELRIC

There is no apparent rationale for the low estimates of TELRIC, embodied in the FCC's proxies. How can those values be so much lower than the actual average costs of providing telephone service today? The obvious possibilities do not offer any satisfactory explanation.

- The low estimates do not derive from scale economies. We have noted that TELRIC embodies limited scale economies. Moreover, even our estimates of ELRIC, which

embody greater scale economies than previous econometric studies, are far higher than the FCC's proxies which purportedly reflect TELRIC.

- The low estimates do not derive from *consistent* economic modeling of capital costs; *i.e.*, the use of economic value of capital and economic depreciation instead of regulatory book value of capital and regulatory depreciation. Our top-down analysis is based on economic value of capital and economic depreciation; it yields incremental-cost estimates that substantially exceed the FCC's proxies. Indeed, our top-down estimates substantially exceed the FCC's proxies, even where capital valuation and economic depreciation are based on Hatfield's green-field model. An important reason why the HAI cost estimates are so much lower than ours is that the HM is self-contradictory in using economic valuation of capital and regulatory depreciation. If the HAI estimates of capital requirements are anywhere near accurate, regulatory depreciation is a wholly inadequate proxy for economic depreciation (which should be used in any economic cost analysis).
- In principle, waste and inefficiency could lead to a disparity between actual operating costs and TELRIC (for an efficient operator). However, the claims to this effect by LEC adversaries are remarkably devoid of specifics. If CLECs are to be given low interconnection prices on the basis of alleged waste and inefficiency, there should be some specific and defensible evidence. In this regard, bottom-up cost estimates, especially those based on a green-field model for serving an idyllic community, do not constitute evidence of waste and inefficiency. Costs of providing telephone service in the real world are often likely to exceed the costs estimated in such models — apart from any waste and inefficiency. Evidence on waste and inefficiency

involves identifying specific instances where real-world managers made errors that increased costs and did not lead to commensurate increases in quality of service.[34]

The above possibilities cannot justify the low estimates of TELRIC embodied in the FCC proxies for loops and switching. We believe that those proxies should not be used in the absence of a convincing rationale for the differences between the proxies and real-world operating costs.

When cost estimates diverge so far from actual average costs with no convincing explanation, there is a real possibility that the cost model has run amok. For that reason, a reconciliation of bottom-up and top-down cost estimates should include a careful examination of such disparities. We believe that such a process would likely lead to higher interconnection prices for loops and switching than the current FCC proxies.

## XI. Conclusion

We have demonstrated how econometric tools can be used to estimate costs on the basis of "real-world" network operations. One important advantage of the approach we utilize is its ability

---

[34] The electric power industry offers a useful comparison in this regard. Analysts of that industry have identified specific decisions (*e.g.*, decisions to build nuclear plants and decisions to increase generating capacity rather than purchasing less-costly power) that led to sizable cost increases. They have attempted to quantify the extra costs resulting from such decisions. One might argue that the TELRIC of electric power should not include the extra costs, so identified.

The debate in telecommunications has not reached that point. LEC adversaries have yet to identify the analogues of nuclear power plants and excessive self-supply, let alone quantify their effects. Only two *specific* activities are cited by HAI as evidence of waste and inefficiency:

1. Offerings of video dialtone service. Video dialtone activities are a small part of the total LEC business and could not conceivably account for much of the disparity between HAI's cost estimates and ours. Furthermore, video dialtone activities have been approved by the Commission, and may turn out to be successful enterprises.
2. Official (*i.e.*, self-supplied) interLATA services of BellSouth in Florida. BellSouth has rebutted the claims of excessive costs. In any event, the costs that HAI cite as excessive apply to interoffice facilities, which are excluded from our study. Those costs cannot explain any part of the disparity between HAI's estimates and ours.