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Global Crossing

May 11, 2000

EX PARTE

Ms. Magalie Roman Salas
Secretary
Federal Communications Commission
445 12th Street, S.W., TW-A325
Washington, D.C. 20554

Re: CC Docket Nos. 96-262, 94-1, 99-249, and 99-45 (CALLS Proposal)

Dear Ms. Salas:

In comments and reply comments filed with the Commission and in *ex parte* meetings with Commission staff, Global Crossing urged the Commission to: (1) adopt a separate glidepath for aggregate price cap reductions for mid-size carriers under the modified CALLS plan; and (2) require that tandem switched rates receive at least a proportionate share of the July 1, 2000 reductions under the modified CALLS plan. To further justify why a separate negotiated glidepath is warranted for mid-size carriers, we have updated the data used in our earlier study and conclude, yet again, that a differential for mid-size carriers is warranted and would serve the public interest.

In Global Crossing's reply comments, we provided evidence demonstrating that mid-size carriers can be expected to have productivity growth less than the productivity growth of the regional Bell Operating Companies ("RBOCs"). Frontier Telephone of Rochester ("Frontier"), for example, would have a differential of 2.76 percent per year. This estimate was calculated based on the "Centel study" that relied on 1986-1989 data and identified small holding company size and lower unit costs as the main factors causing the differential.

Since the reply comments were filed, the Centel study has been updated and the new study relies on data from 1993 to 1997. The new study reflects major changes in the telecommunications industry since 1986-1989, most notably, the implementation of price-cap regulation. As a result of price cap regulation, the RBOCs have more aggressively exploited the economies of their large size. The differential in productivity growth attributable to holding-company size has therefore substantially increased. At the same time, the differential attributable to low unit cost has disappeared. In the new study, unlike the Centel study, the rate of growth of output was also a significant determinant of

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productivity growth. The explanation for this effect is that companies adding state-of-the-art plant and equipment to meet demand growth enjoy productivity gains as a result. Companies with slower output growth have less opportunity to enjoy these productivity gains.

All in all, the new study estimates that the differential in expected productivity growth between the RBOCs and mid-size carriers has increased substantially. Applying the new study to Frontier yields the following results:

- Differential for small holding-company size: 4.1 percent per year
- Differential for slower output-growth rate: 1.1 percent per year
- **Total differential: 5.2 percent per year**

These new results provide strong additional evidence that mid-size carriers should be afforded a separate glidepath for aggregate price cap reductions under the modified CALLS plan. A copy of the new study is attached to this filing. To the extent that the Commission would like to discuss these issues further, please do not hesitate to contact me at (202) 872-0063.

Respectfully submitted,

John S. Morabito

cc: Dorothy Atwood
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VARIATION IN PRODUCTIVITY GROWTH AMONG TELEPHONE COMPANIES

Prepared for

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May 10, 2000

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VARIATION IN PRODUCTIVITY GROWTH AMONG TELEPHONE COMPANIES

EXECUTIVE SUMMARY

In 1997, the FCC re-prescribed the amount by which it annually adjusts price caps for incumbent local exchange carriers subject to the price cap rules. The revised price cap adjustment required price cap local exchange carriers (LECs) to reduce inflation-adjusted prices for interstate access services by an "X-factor" of 6.5 percent per year. In that order, the FCC decided to apply the same productivity factor to all price-cap LECs.

Pursuant to petitions for review of the Commission's order, the United States Court of Appeals for the District of Columbia Circuit reversed and remanded the Commission's decision. In November 1999, the Commission issued a *Further Notice or Proposed Rulemaking*[1] seeking comment on how to re-prescribe the productivity factor.

The FCC's price cap plan adjusts rates based on an economy-wide cost index (that reflects economy-wide productivity growth), an additional productivity adjustment (reflecting the reasonable expectation of additional productivity growth) and "exogenous" factors. Herein, we adduce evidence that operators with a smaller holding company and/or slower growth of output should have a lower productivity adjustment than is applied to the divested Bell Operating Companies (BOCs) and GTE. Productivity adjustments that fail to reflect these differences will cause these carriers to earn unreasonably low returns. When the productivity adjustment is developed from analysis of the BOCs (as in the FCC's most recent TFP Study), smaller and slower-growth carriers are unduly penalized.

In this paper, we argue that application of a single productivity factor to all LECs is unfair. Differences in operating conditions of carriers cause differences in the productivity gains that can be reasonably expected. Through our most recent quantitative economic analysis, we show in this paper that expected productivity gains are lower for carriers having smaller holding companies and/or a lower output growth rate. The statistical model described below indicates that, if Company A's holding company is twice the size of Company B's, Company A's productivity can be expected to exceed that of Company B's by 0.94 percent per year.[2] It also indicates that, for every 1% that the annual growth rate of Company A exceeds that of Company B, Company A's productivity can be expected to exceed that of Company B by 1.40 percent per year. The finding is statistically significant in a regression analysis performed on pooled, time-series data for telephone properties for the years 1993-1997. This model indicates

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[1] FNPRM, *In the Matter of Price Cap Performance Review for Local Exchange Carriers* (CC Docket No. 94-1) and Access Charge Reform (CC Docket No. 95-262), released November 15, 1999.

[2] This is calculated as the product of the estimated coefficient (.013630) and *ln* 2 (0.6931).

that the expected productivity growth for Frontier Telephone of Rochester is 5.2 percent per year lower than that of the RBOCs.[3]

[3] Based on the weighted average RBOC and Frontier Telephone of Rochester data for the period 1993-1997.

I. INTRODUCTION

A. The Price Cap Performance Review FNPRM

In 1997, the FCC re-prescribed the amount by which it annually adjusts price caps for incumbent local exchange carriers subject to the price cap rules. The revised price cap adjustment required price cap local exchange carriers (LECs) to reduce inflation-adjusted prices for interstate access services by an "X-factor" of 6.5 percent per year. In that order, the FCC decided to apply the same productivity factor to all price-cap LECs.

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The FCC's price cap plan adjusts rates based on an economy-wide cost index (that reflects economy-wide productivity growth), an additional productivity adjustment (reflecting the reasonable expectation of additional growth) and "exogenous" factors. Herein, we adduce evidence that operators with a smaller holding company and/or slower growth of output should have a lower productivity adjustment than is applied to the divested Bell Operating Companies (BOCs) and GTE. Productivity adjustments that fail to reflect these differences will cause these carriers to earn unreasonably low returns. When the productivity adjustment is developed

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from analysis of the BOCs (as in the FCC's most recent TFP Study), the smaller and slower-growth carriers are unduly penalized.

B. Background

Over the last ten years, a considerable body of argument and evidence has been adduced indicating that variations in the conditions under which different carriers operate cause significant differences in the productivity gains they can be reasonably expected to make.

- Our 1989 study demonstrated that Cincinnati Bell, while maintaining a high level of efficiency and running a low-cost operation compared to other carriers, exhibited a slower rate of productivity growth.[5] Not surprisingly, since Cincinnati Bell was already operating efficiently, further improvements were more difficult to come by.

- In 1991, we utilized data on a substantial number of LECs with holding companies of different sizes and a regression analysis to show that productivity gains were systematically lower (in a statistically significant manner) for smaller holding companies and for carriers that already have lower average costs.[6]

- In 1997, Rohlfs & Pehrsson updated the Cincinnati Bell numbers and found that, while Cincinnati Bell had quite substantially lower costs than the RBOCs, its rate of productivity growth remained (not unexpectedly) significantly lower.[7]

- In 1998, Rohlfs & Pehrsson measured Cincinnati Bell's and Aliant's productivity using the productivity model developed by the FCC's staff and found them both to be significantly lower than the RBOCs'.[8]

- Recently, Rohlfs & Pehrsson were able to utilize newly available data to estimate productivity gains for Citizens Communications' New York property and found that its productivity gains were also significantly below the RBOCs'.[9]

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[5] *See* NERA, "Incentive Regulation and Estimates of Productivity," prepared for Cincinnati Bell, 9 June 1989.

[6] *See* Rohlfs, *op. cit.*

[7] "One Size Does Not Fit All: The Inadequacy of a Single X-Factor for All Price-Cap Companies," Prepared for Cincinnati Bell, 1997.

[8] "One Size Does Not Fit All: Further Evidence," prepared for Cincinnati Bell and Aliant, 23 April 1998.

[9] "Analysis of Productivity Trends of Citizens Communications," prepared for Citizens Communications, 21 January 2000.

The theoretical underpinnings of these findings are fairly straightforward. With respect to our current study, the following considerations are important:

- LECs are differently situated and possess different characteristics affecting their costs and abilities to exploit various administrative and operational economies. Some LECs, by virtue of their slow rate of (exogenous) growth, have less opportunity to realize productivity advances through deployment of new technology or exploitation of economies associated with growing output. A variety of technical and operational economies that can be exploited in areas where demand is growing are not available to LECs operating in non-growth or even declining areas. At the same time, smaller holding companies are less well positioned to exploit economies from more intensive use (*viz.*, cost spreading) of various administrative resources and systems.

In 1991, we undertook a quantitative statistical analysis[10] to determine the principal sources of variation in observed productivity gains among different LECs. The study was a pooled time-series cross-section analysis. The sample included data from 21 Bell companies and 22 independent companies from 1986 to 1989.

The dependent variable was growth in total factor productivity ("TFP"). In the calculation of TFP, output was measured in physical units; *viz.*, access lines and dial-equipment minutes ("DEMs"). Estimates of marginal costs were used as weights to calculate aggregate output. Inputs consisted of capital, labor and materials.

In an effort to arrive at a robust explanatory relationship, we regressed our measure of TFP growth against a variety of explanatory variables conceived to capture a variety of potential independent influences on productivity gains. These included holding company size (to gauge the increased potential for cost savings through centralization), a cost index (to test the hypothesis that lower costs spell lower anticipated productivity gains), time effects (to check for the effect of any omitted time-dependent variables), the digital equipment share (to gauge the potential for productivity advance through deployment of digital switches), age of plant (again to try to capture the potential for productivity advance through modernization of plant & equipment), growth rate (to reflect effect of installing modern equipment to meet demand growth) and, finally, usage per access line (to reflect the fact that the productivity of

[10] *See* Rohlfs, *op. cit.*

each of these outputs may vary and, therefore, that productivity may differ when the mix differs from the average).

In our regressions, the first three variables (*i.e.*, holding-company size, cost level and fixed time effects) were statistically significant, while the remaining variables were not.[11]

Most recently, we applied the 1991 Centel model using 1997 values of the explanatory variables to estimate the differential between the expected rate of productivity growth of Frontier Telephone of Rochester, Inc. and that of the RBOCs.[12] The Rochester company is Global Crossing's largest operating company and is the only Global-Crossing company for which sufficient data were available to conduct the analysis. It accounted for 57 percent of Global Crossing's access lines in 1997. The estimated differential in productivity growth between the RBOCs/GTE and the Rochester company indicated by that analysis was 2.76 percent per year.[13]

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[11] In our earlier paper, we noted that the effects of digital share and age of plant were likely to be incorporated to some extent in our cost-level explanatory variable.

[12] J. Rohlfs and K. Pehrsson, "Productivity Differentials Among Local-Exchange Carriers", attachment to *Reply Comments* of Global Crossing North America, Inc. in CC Docket No. 94-1, April 17, 2000.

[13] The RBOC average is a weighted average, using total costs as weights. These weights are the theoretically correct measure.

II. MODEL

A. Approach

The modeling approach of our current study is similar to that used in the 1991 study of differences in productivity gains among telephone companies,[14] with some modifications which are described below.

The modeling approach uses regression analysis of various hypothetical relationships between change in total factor productivity (the dependent variable) and several candidate determinants (independent variables). The model is developed by testing the significance of several intuitive determinants of productivity across all observations in the data set, in order to derive a robust explanatory relationship. After that step is completed, it is then possible to test whether the determinants vary significantly across the companies that are subject to price caps. The model is based on the following general structure:

$$\Delta TFP = a + b_1x_1 + b_2x_2 + b_3x_3 \ldots..$$

where:

ΔTFP = Gain in Total Factor Productivity, and

a = Intercept

$x_1, x_2, x_3 \ldots$ = Determinants of Productivity

An important difference between the approach taken in the 1991 Centel study and the current study is the distinction between regulated and unregulated costs. The productivity model developed by the FCC Staff does not include outputs associated with unregulated activities. This omission is manifest in the exclusion of Miscellaneous Revenues, which includes revenues from unregulated activities.

As a matter of theory, a productivity model that excludes the outputs of unregulated activities should also exclude the inputs used to produce them. Otherwise, output growth and

[14] J.H. Rohlfs, "Differences in Productivity Gains Among Telephone Companies," prepared for Centel, 3 September, 1991.

input growth are inconsistent and cannot be compared to estimate total factor productivity. Nevertheless, the FCC Staff Model does not exclude the inputs used in unregulated activities. Failure to exclude such inputs is theoretically suspect. This method may be reasonable for estimating RBOC productivity growth, since unregulated activities constitute only a small part of RBOC output. However, it is not appropriate for measuring productivity of non-RBOC companies. Non-RBOC companies' unregulated activities are often a larger fraction of total output and also follow quite a different pattern than regulated activities, so regulated activities are not an adequate proxy for unregulated activities. Since the data base used for this modeling effort includes non-RBOC observations, we exclude unregulated inputs from our analysis.

B. Dependent Variable (ΔTFP)

The dependent variable is the loss or gain in annual productivity experienced by the observed entity (individual company or study area). The precise definition of productivity change is presented in Section III. It is essentially the excess (or shortfall) of the percentage change in outputs over the percentage change in inputs, after adjusting for the effects of price changes.

C. Candidate Independent Variables

Several intuitive explanatory factors were tested in developing the model. Most of them have arisen in other discussions of productivity drivers. A discussion of each of the candidate factors, and the reasons for considering them as potential drivers, are discussed below.

1. Holding Company Size

The size of the holding company was included as a candidate variable because it may be expected to yield opportunities for productivity growth through centralization. The natural logarithm of the holding company size was used as the regressor because growth in productivity would not be expected to increase linearly with size (for large differences in size). The holding company size was measured in terms of access lines.

2. Cost Level

A variable measuring the existing level of cost was intended to test the theory that if a company has a lower cost level to begin with, it will have less opportunity for further cost reductions in the future. This will translate into lower productivity growth.

3. Time Effects (Fixed)

The model was tested using a fixed effect variable for each successive year in the time period analyzed, so as to account for variables which might be missing from the specified model. This approach avoids bias that could occur due to missing variable to the extent that such missing variables cause equal productivity gains across all telephone properties for a given year. Because the data are pooled (meaning they include both cross-telephone property and time-series observations), there are sufficient degrees of freedom to support this type of robust model even with inclusion of time-specific variables. The fixed effect variables capture important differences across time periods (such as growth of the Internet) which might not be fully captured in the other variables in the model but that may affect measured productivity gains.

4. Growth Rate

To accommodate demand growth, LECs generally need to install additional plant and equipment. That plant and equipment usually embodies the latest technology and is a source of productivity growth. Such growth is enjoyed to a lesser extent by LECs with slow growth. To measure output growth, we collected data on the number of access lines[15] and total dial equipment minutes (DEMs), weighted by their relative marginal costs.

The formula used to determine growth in output as the percentage change in the following:

$$Number_{loops} * MC_{loops} + Number_{minutes} * MC_{minutes}$$

[15] We excluded digital special access lines because the data indicated that several companies had changed the reporting from line counts to voice-line capacity equivalents during the period of analysis. The result was that, for some companies, there was reported a dramatic one-time increase in digital special access lines. In order to isolate this data anomaly, digital special access lines were subtracted from the total access line count reported in ARMIS.

Sources of data and marginal cost estimates are discussed further in Section III.

5. Density

We also tested the impact of the density of access lines in the area served. Data on access lines were taken from ARMIS and data on the square miles served by each property were taken from records data compiled by NECA reflecting the results of a 1996 survey mandated by the FCC for use in Universal Service Fund reforms. The density variable was tested because a disproportionately large fraction of the costs of carrier services in less densely-populated areas are the sunk costs of long loops which are subject to little or no technological progress.

6. Usage Per Access Line

The mix of the two outputs, minutes of use and number of access lines (as well as the productivity associated with each), may vary. Therefore, the productivity could be expected to differ where the ratio is significantly different than the average due to high or low usage per access line.

7. Excluded Variables

There are two independent variables that were tested in the 1991 study that were not tested here. One was the percent of digital/electronic equipment. This variable was considered to be much less important for this more recent data series, since almost all switching equipment has now been upgraded to digital. The other variable tested in the 1991 study is age of plant. This was not evaluated here because data are lacking. Age of plant is generally highly collinear with the growth rate. That is, companies with faster growth tend to have newer plant. Thus, our growth rate variable may pick up effects due to age of plant.

8. Significance of Candidate Variables

The variables that proved to be statistically significant in the final equation were holding company size, growth in output, and fixed time effects. The remaining variables (cost level, density, and usage per line) were not statistically significant and were not included in the final equation.

A possible reason why cost level was not significant here, while it was significant in regressions run on older data, is the RBOCs' response to price cap incentives. (In this regard, we note that at the state level RBOCs were regulated more tightly than many small carriers, prior to price caps.) Price cap incentives may have induced RBOCs recently to more aggressively exploit the economies of their large sizes that they did during 1986-1989 (the estimation period of the earlier study). This RBOC response may be reflected in this latest regression equation in two ways:

- It lessened the impact of cost level as a driver of productivity changes.
- It accentuated the impact of holding company size (source of economies of scale) as a driver of productivity changes.

A possible reason why density (not tested in the earlier study) was insignificant in this analysis is that there were so few rural telephone properties included in the sample. Usage per line, though a plausible determinant of productivity, did not significantly contribute to explaining productivity differences in both the current and earlier regression analysis.

III. DATA

A. Data Series and Sources Used

The database includes 35 separate telephone properties. 17 of these are divested Bell companies, 8 are GTE properties, 6 are Sprint properties, and 4 are other independent properties. These properties were chosen on the basis of availability of data.

Data were collected at the study area, where all data were available at that level. In most cases, the observations were at the study area level. However, in some cases (particularly GTE), only operating company level data were available for some of the candidate variables being tested, so the other (study area) data were aggregated to operating company level.

For each of the 35 operating entities, data were collected for each of the years 1992-1997 for which all data were available. In some cases, complete data were available for only some of the years. Where data were at the telephone operating company level, years were included only where the coverage area remained the same (*e.g.*, study areas were not acquired or divested). Otherwise, the data were excluded because a change in the coverage area of a telephone property might affect its productivity. Such exclusions occurred primarily in the GTE properties during 1992-1994, when there was significant activity in acquisition of CONTEL properties and trading of other properties with Citizens and Alltel.

Information of the following companies were included: BellSouth, Bell Atlantic (D.C.), Central Telephone Co., Bell Atlantic (Maryland), Contel of the South, Bell Atlantic (Virginia), Bell Atlantic (West Virginia), Bell Atlantic (Delaware), GTE California, GTE Florida, GTE of the Midwest, GTE of the Northwest, GTE of the South, Illinois Bell, Aliant Telecommunications Co., Michigan Bell, Indiana Bell, New England Telephone & Telegraph, Bell Atlantic (New Jersey), New York Telephone, Ohio Bell, Bell Atlantic (Pennsylvania), Pacific Bell (California), Nevada Bell, Rochester Telephone, SNET, Southwestern Bell, U S West, United of the Southeast, Carolina Telephone and Telegraph of North Carolina, United Telephone of New Jersey, United Telephone of Ohio, United Telephone of Pennsylvania, Wisconsin Bell, and Cincinnati Bell.

There were 131 observations included in the regression.

B. Definition of variables

1. Measures of Productivity

Productivity growth is the increase in output over the increase in inputs. In other words, it is a measure of efficiency of production, and can be thought of as the change in the number of units that can be produced for a constant cost. Productivity gain is the same as a change in the per-unit cost of production, assuming input unit costs remain constant. To model productivity growth, the model must isolate changes in input quantities from changes in input prices (e.g., a rise in cost of capital). Reductions in input prices do *not* generally reflect more efficient operation but, rather, are a change in cost largely beyond the control of the firm. To isolate the effects of productivity, we control for changes in input prices (by using price indices for the inputs of labor, capital, and material costs) for each year in the series and accounting for the proportion of each expended by the individual companies.

a. Output Quantity Index

Due to the difficulty of obtaining a consistent series of output-price index data, we could not use deflated revenues as our output quantity index. Instead, we used data on the physical output quantities as the output quantity index. This approach was used in the 1991 Centel Study and is also used in the FCC Staff's models.

Growth in Total Factor Productivity can be derived by the difference between proportional changes in quantity and the proportional change attributable to price of inputs, or:

$$\Delta TFP = \frac{\Delta \text{Quantity Produced}}{\text{Quantity Produced}} - \frac{\Delta \text{Quantity Input}}{\text{Quantity Input}}$$

b. Quantity Produced

Quantity data were available on the two primary outputs of each telephone property – access lines and usage (dial-equipment minutes).[16] Arguably, inclusion of additional

[16] The use of only two outputs in this calculation is analogous to using only two quantity variables – access lines and usage – in a cost model.

components of output beyond these two measures may increase accuracy of the equation. However, no such data series were readily available. Besides, access lines and usage comprise the primary outputs of LECs.

Data on access lines by year and telephone property were extracted from the FCC's ARMIS 43-08 reports. As mentioned earlier, we excluded digital special access lines because the data indicated that several companies had changed the reporting from line counts to voice-line capacity equivalents during the period of analysis. The result was that, for some companies, there was reported a dramatic one-time increase in digital special access lines. In order to isolate this data anomaly, digital special access lines were subtracted from the total access line count reported in ARMIS. Data on total dial equipment minutes (DEMs) by year and telephone property were collected from NECA compilations posted on the FCC's website. The total DEM figures reflect access, intrastate toll and local calls. They also reflect the more intensive use of switching equipment by certain calls, providing a better measure of actual output represented by processing those calls. The output index used is a weighted average of these two primary inputs.

Estimates of the marginal cost were used to weight the access and usage proportions of the output in this model. The alternative of weighting by revenue share was rejected because in a regulated industry, such as telephone service, price may not accurately reflect marginal cost. Therefore, direct estimates of marginal cost were used for this analysis.

For our base case, we used the estimates from Scenario A of the SPR Top Down Cost Model.[17] They are $30 per access line per month and $0.0017 per DEM. The absolute level of these marginal costs is not important for the statistical analysis. All that matters is the ratio of the two marginal costs. Thus, the same results would be obtained if we assumed that the marginal costs of access lines is $18 per line per month and the marginal cost of DEMs is $0.001 per minute. We note that the ratios which we now use are more reasonable than those used in the 1991 study. The relative marginal cost of usage compared to lines has fallen significantly in the intervening period since the earlier study was conducted. The implicit

[17] Strategic Policy Research, "A New Set of 'Top Down' Incremental Cost Measures (Revised)," filed before the FCC, CPD Docket No. 97-2, February 18, 1997.

assumption in this measure is that the ratio of access marginal cost to usage marginal cost is the same for all companies and all time periods.

The precise formula used to determine the change in quantity produced is as follows:

$$\frac{(\text{Growth}_{\text{loops}} * \text{Number}_{\text{loops}} * \text{MC}_{\text{loops}}) + (\text{Growth}_{\text{minutes}} * \text{Number}_{\text{minutes}} * \text{MC}_{\text{minutes}})}{(\text{Number}_{\text{loops}} * \text{MC}_{\text{loops}}) + (\text{Number}_{\text{minutes}} * \text{MC}_{\text{minutes}})}$$

where;

$\text{Growth}_{\text{loops}}$	= Growth rate for telephone access loops
$\text{Number}_{\text{loops}}$	= Number of telephone loops
Mc_{loops}	= Annual Marginal Cost of telephone loop ($362.04)
$\text{Growth}_{\text{minutes}}$	= Number of minutes of usage (DEMs)
$\text{Number}_{\text{minutes}}$	= Number of minutes of usage (DEMs)
$\text{MC}_{\text{minutes}}$	= Marginal Cost of minute of usage ($.0017)

This formula provides a measure of the growth of output.

c. Quantity of Input

Changes in input quantities are calculated by examining the *real* change in input expenditures. Subtracting the changes in price of inputs removes effects that are attributable to shifts in factor prices, rather than increased input quantity. Expenditures for each of the three input factors – capital, labor, and materials – are adjusted for price changes and multiplied by the respective contribution to overall input cost. The summation of the total reflects growth (or shrinkage) in total input quantity. The precise formula used to measure changes in quantity of input factors is as follows:

$$(\text{Growth}_{\text{cap exp}} - \text{Growth}_{\text{cap price}}) * (\text{Cost}_{\text{cap}} / \text{Cost}_{\text{tot}})$$
$$+$$
$$(\text{Growth}_{\text{labor}} - \text{Growth}_{\text{labor price}}) * (\text{Cost}_{\text{labor}} / \text{Cost}_{\text{tot}})$$
$$+$$
$$(\text{Growth}_{\text{mat exp}} - \text{Growth}_{\text{mat price}}) * (\text{Cost}_{\text{mat}} / \text{Cost}_{\text{tot}})$$

where:

$Growth_{cap\ exp}$	= Growth rate for capital expense
$Growth_{cap\ price}$	= Growth rate for capital price
$Cost_{cap}$	= Capital expense
$Cost_{tot}$	= Total cost
$Growth_{labor}$	= Growth rate for labor expense
$Growth_{labor\ price}$	= Growth rate for labor price
$Growth_{mat\ exp}$	= Growth rate for materials expense
$Growth_{mat\ price}$	= Growth rate for materials price
$Cost_{mat}$	= Materials expense

2. Sources for Measures of Input

The exact component of the variables used in the formula for changes in input quantity are discussed below:

a. Cost Indices

(1). General

Financial data used in deriving the cost indices were obtained from the FCC's ARMIS reporting system. Our measures of physical outputs – access lines and DEMs – are both regulated outputs. Therefore, we separate out unregulated activities of all companies. Where the unregulated portion of cost was not separately reported (e.g., employee compensation) we estimate the regulated portion by multiplying each cost element by the ratio of regulated operating costs to total operating costs.

(2). Materials expenses

Total *non-regulated* operating expenses (as reported) less regulated compensation, depreciation and operating taxes.[18] Operating and depreciation expenses were taken from the ARMIS 43-01 reports. Operating taxes and compensation figures were taken from the ARMIS 43-02 reports.

(3). Capital costs

Capital costs equal the capital stock multiplied by the price of capital multiplied by ratio of regulated to total operating expenses.

[18] The portion of these expenses attributable to regulated activity was estimated by applying the ratio of regulated to total operating expenses to the total amount reported.

(i) Capital Stock

Capital stock for 1997 was estimated as the net plant for 1997. We use net plant in 1997 as a proxy for economic value of plant. This value reflects GAAP accounting methods for any company that switched to GAAP in 1997 or earlier. Values of prior years' net plant were estimated by the following method:

$$\text{Capital Stock}_t = \frac{(\text{Capital Stock}_{t+1} - \text{TPIS Additions}_{t+1}) * \left(\frac{\text{BEA Composite Price Index}_t}{\text{BEA Composite Price Index}_{t+1}}\right)}{(1 - \text{Predicted Depreciation Rate})}$$

This approach of "backing-out" capital stock from 1997 reported net plant and economic depreciation has the benefit of avoiding the inconsistencies in reported net plant that may have been precipitated by the transition to GAAP reporting methods during the time period.

The index used to estimate inflation in cost of capital is the BEA Composite Asset Price Index used in the FCC's 1999 Staff TFP Study[19].

The 1997 Net Plant and annual TPIS Additions data are from the ARMIS 43-02 reports.

Because recent depreciation rates varied significantly among properties, due to varying accounting methods and age of plant, a single estimate of depreciation of 12.5 percent (of net economic value of capital) per year was used across all properties and years to generate the capital stock estimates.

(ii) Price of Capital

The price of capital is estimated as the nominal interest rate plus a 3% estimated risk premium plus the predicted tax rate plus the predicted depreciation rate.

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[19] *Further Notice of Proposed Rulemaking*, CC Docket No. 94-1 and CC Docket No. 96-262 (Released: November 15, 1999), Table B-7.

The nominal interest rate was measured by averaging the rate for Long-Term U.S. Government Securities (unweighted average on all outstanding bonds neither due nor callable in less than 10 years) and 10-Year Treasury Constant Maturity Rate (average of business days), both reported in H.15 Release, Federal Board of Governors.

The predicted tax rate is estimated for all companies and years at 7.5% and the predicted depreciation rate is estimated for all companies and years at 12.5%.

(4). Labor expenses

Labor expenses were estimated as the compensation reported on the ARMIS 43-02 reports multiplied by the ratio of regulated to unregulated operating expenses.

(5). Total Cost

The formula used to calculate total cost was: labor expenses plus materials expenses plus capital costs.

b. Price Indices

(1). Price of Labor

The deflator for labor is the Labor Price Index used in the FCC's 1999 Staff TFP Study[20]. This series allegedly adjusts for the impact of exogenous changes in labor compensation (due, in part, to employee buy-outs that occurred upon adoption of price caps).

(2). Price of Materials

The index used to deflate the materials expenses is the Materials Price Index used in the FCC's 1999 Staff TFP Study.[21]

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[20] *Further Notice of Proposed Rulemaking*, CC Docket No. 94-1 and CC Docket No. 96-262 (Released: November 15, 1999), Table B-13.

[21] *Further Notice of Proposed Rulemaking*, CC Docket No. 94-1 and CC Docket No. 96-262 (Released: November 15, 1999), Table B-13.

(3). Price of Capital

The index used to deflate the capital expenses is the BEA Composite Asset Price Index used in the FCC's 1999 Staff TFP Study.[22]

[22] *Further Notice of Proposed Rulemaking*, CC Docket No. 94-1 and CC Docket No. 96-262 (Released: November 15, 1999), Table B-7.

IV. STATISTICAL RESULTS

A. Model: Productivity as a Function of Holding Company Size and Growth of Output Index

The final equation that best explained changes in productivity is the following:

$$\Delta TFP = 0.013630\ ln\ x_{hcsize} + 1.395296\ x_{growth} - 0.253626\ x_{1994} - 0.117126\ x_{1995} - 0.142407\ x_{1996} - 0.160009\ x_{1997} - 0.287293\ x_{AR1}$$

where:

ΔTFP	=	Gain in Total Factor Productivity
lnx_{hcsize}	=	Log of size of holding company (measured in access lines)
x_{growth}	=	Percentage growth in output index
x_{1994}	=	Fixed effect for the year 1994
x_{1995}	=	Fixed effect for the year 1995
x_{1996}	=	Fixed effect for the year 1996
x_{1997}	=	Fixed effect for the year 1997
x_{AR1}	=	First-order autoregressive coefficient of the error

1. Statistical Fit

r^2	0.27
r^2 ADJ	0.24
Standard Error	0.090
F-statistic	7.70
t-statistics:	
lnx_{hcsize}	2.1
x_{growth}	3.7
x_{1994}	-3.0
x_{1995}	-1.9
x_{1996}	-2.1
x_{1997}	-2.3
x_{AR1}	-3.4

The coefficient for lnx_{hcsize} was statistically significant at the 5-percent level. The coefficient for x_{growth} was statistically significant at the 1-percent level. The fixed year effects, considered together, were statistically significant at the 1-percent level (x_3^2 = 12.738). The r^2 statistic is only moderate because productivity growth is a highly volatile series. The autoregressive coefficient was large and negative and statistically significant at the 1-percent level. It indicates that unexpectedly high productivity growth in one year is associated with (otherwise) unexpectedly low productivity growth the following year, and vice versa.

2. Interpretation of Results

The statistical relationships developed in this most recent model indicates that the primary determinants of productivity growth are the size of the holding company and the growth rate in output. The size of the holding company likely captures the economies of scale which may be achieved through centralization of operations. This model indicates that, if Company A is twice as large as Company B, Company A's productivity growth will exceed that of Company B by 0.94 percent per year.[23] It also indicates that, if Company A's *rate* of growth in output is 1-percent higher than that of Company B, that Company A's productivity growth will exceed that of Company B's by 1.40 percent per year. The latter effect reflects the fact that new plant installed to meet demand growth is likely to embody the latest technology and contribute to productivity growth.

B. Sensitivity Analysis

1. Marginal Cost

We performed a sensitivity analysis with respect to our marginal cost assumption, substituting the marginal cost estimates that were used in the original study of $300 per access line per year and $0.01 per DEM.[24] Using these alternative marginal costs, the expected

[23] This is calculated as the product of the estimated coefficient (0.013630) and *ln* 2 (0.6931).

[24] These figures were based on estimates used in a study by Perl and Falk filed by the United States Telephone Association (USTA) in the price-cap proceeding (CC Docket 97-313) in 1989. (*See* Lewis Perl and Jonathan Falk, *The Use of Econometric Analysis in Estimating Marginal Cost*, (Presented at Bellcore and Bell Canada Industry Forum: San Diego, California), April 6, 1989.

differential in productivity growth between Frontier Telephone of Rochester and the RBOCs is 5.8 percent per year (compared with a 5.2 percent per year differential using the marginal costs assumed in the model). We conclude that the estimated productivity differential is robust with respect to alternative plausible estimates of marginal costs.

2. Merger Activity

We also performed a sensitivity analysis with respect to excluding 1997 data. This was performed because the merger activity in 1997 (Pacific Telesis and SCB and also Bell Atlantic and NYNEX) caused a sudden increase in the holding company size for observations associated with the merged entities. It is not clear whether the effect of the larger holding company size would be felt immediately following a merger. Excluding 1997 data from the sample yields an expected differential in productivity growth between Frontier Telephone of Rochester and the RBOCs of 6.4 percent per year (compared with a 5.2 percent per year differential when including 1997 data). We conclude that the estimated productivity differential is conservatively low.

C. Individual Company Forecasts

Using this model, it is possible to forecast expected *relative* productivity gains among firms.[25] Using 1993-1997 values, we estimated the average productivity of Frontier Telephone of Rochester relative to the weighted[26] average of the RBOCs. Using this method, the predicted productivity growth for Frontier Telephone of Rochester is 5.2 percent per year lower than that of the RBOCs. We conclude that Rochester is likely to experience substantially lower productivity growth than will the RBOCs, on average. Analysis of the data reveals that the major portion (4.1 percent per year) of the predicted productivity growth differential between Frontier Telephone of Rochester and the RBOCs is attributable to holding company size. (Only 1.1 percent per year of the differential is attributable to growth of output.) This finding

[25] Because we have captured accounting changes and other one-time impacts on productivity via the fixed time effects (dummy variables), the model yields only estimates of relative productivity and cannot be used to estimate absolute productivity for firms.

[26] RBOC observations were weighted by total operating expenditures.

is consistent with previous models that have found holding company size to be an important determinant of productivity growth.

The model indicates a similar differential for Cincinnati Bell. We calculated that the productivity growth for Cincinnati Bell is 3.7 percent per year lower than that of the RBOCs. In the case of Cincinnati Bell, holding company size yields a predicted productivity growth differential between Cincinnati Bell and the RBOCs of 4.0 percent per year. Relative growth of output reduces that differential by 0.3 percent per year, to total the combined effect of 3.7 percent per year.

V. IMPLICATIONS FOR PRICE CAPS

The modeling exercise described above demonstrates that Frontier Telephone of Rochester cannot reasonably be expected to have the same productivity growth as the RBOCs. On the contrary, it is likely to have substantially slower productivity growth. This model adds to the significant body of evidence that a one-size price-cap plan does not fit all LECs. It is unfair for all firms, regardless of circumstance and prospect for productivity growth, to be held to the same productivity factor.