

their own past values. Such processes are called self-predicting. To show how this would work, GTE demonstrates the process on one of the three potential price cap formulas, the LEC direct method.

The process would begin by calculating the PCI adjustment, using the direct formula without smoothing for each previous year:

$$y_t = \% \Delta W_{LEC} - \% \Delta TFP_{LEC} \quad t=0, \dots, T-1,$$

that is, for each period from as long a past period as possible to the present. Let T represent the desired forecast year for the PCI adjustment factor. Then, a time series analysis is done on the series with the expressed purpose of predicting y_T .

Specifically, a Box-Jenkins identification procedure⁵³ should be done to determine what the values of the autoregressive and moving average components are, and whether or not the series needs to be differenced to remove any trends; e.g., unit roots.⁵⁴ Once the process is identified, it is used to predict future values of the process. GTE

⁵³ The Box-Jenkins identification procedure is a relatively automatic method for determining the characteristics of an ARIMA process before estimation and forecasting. Specifically, by examining the autocorrelation function, the inverse autocorrelation function and the partial autocorrelation function, the number of lags in the various components of the ARIMA can be determined. See, for example, the SAS ETS (Econometrics and Time Series) Manual version 6.10 for a full description and instructions on application.

⁵⁴ Trend removal is a requirement for application of the ARMA part of the ARIMA methodology. See, for example, Harvey, A.C., *The Econometric Analysis of Time Series*, 2nd Edition, Wiley, 1989.

recommends using the resulting one-year-ahead prediction as the price cap index change.⁵⁵ This is discussed in detail in GTE's Appendix D.

The time series methods proposed here by GTE are standard procedures regularly used by statisticians. The specification of the model would be straight-forward and not subject to manipulation or dispute. Standard tests exist for determining whether an optimal specification of the model has been chosen.

Using optimal time-series' methods to forecast the PCI adjustment factor, on the basis of past PCI adjustments, removes the averaging process from gaming. Further, it removes excess volatility that might inhibit investment, and removes any biases that might lead to the wrong types of investment or production.⁵⁶ Indeed, such forecasts automatically remove the random component from the PCI adjustment factor that would cause instability; that is, they automatically smooth. Moreover, once the data are compiled and a new PCI adjustment is calculated from actual data, the forecast can be automatically updated. Such updates can be done easily by simply adding a new data point to the existing model and recalculating the result.

In summary: GTE would support a moving-average concept as a means of eliminating costly and time-consuming reviews while enabling the most recent

⁵⁵ This is consistent with GTE's position since the inception of price caps. "The GTOCs suggest that the percentage change in the inflation index ought to be based on a forecast of what the change will be." See *D.87-313 FNPRM*, 3 FCC Rcd at 3389.

⁵⁶ Statistical tests exist to determine if the PCI adjustment factor is being optimally forecast.

productivity results to be incorporated into an X-Factor – provided that such a method can be shown to accurately forecast price changes on a going-forward basis. Ideally, the price cap should be forecast on the basis of past annual data using a forecasting method that can be easily updated annually. GTE proposes the use of an ARIMA forecasting method to establish a forward looking PCI adjustment factor. This proposal is qualified by the proviso that a sufficiently long series of actual price and TFP growth exist to apply the method; *i.e.*, identify and estimate the underlying ARMA process.

V. The Historical Revenue Method is not an appropriate measure of productivity for the price cap formula since it represents precisely what price caps was designed to avoid. (Issue 2a)

The Historical Revenue Method is better than rate of return regulation – but only by a slim margin. This method is completely inappropriate for price cap regulation because it perpetuates the tie to cost-plus pricing inherent in rate of return regulation. This approach would restore the negatives the Commission was seeking to escape when it chose price cap regulation.⁵⁷ Essentially, the Historical Revenue Method is a backward-looking calculation of the productivity factor that would have produced a specified rate of return. This method, proposed by AT&T,⁵⁸ assumes that the price cap LECs were to be constrained to an 11.25 percent rate of return – which is at the outset an inaccurate assumption. The price cap plan, by way of the sharing mechanism,

⁵⁷ See discussion of the "Rationale for adoption of incentive regulation." *LEC Price Cap Order*, 5 FCC Rcd at 6789-6791.

⁵⁸ See *Fourth Notice* at para. 77.

allowed price cap LECs to earn various "pseudo" rates of return. The lower formula adjustment mechanism was triggered at a lower limit of 10.25 percent, but upper ranges depended on the 50 and 100 percent sharing ranges. Even the sharing mechanism did not constrain LECs to an 11.25 percent rate of return.

In addition, the Historical Revenue Method does not serve as an incentive to increase productivity or to become more innovative. As discussed by NERA,⁵⁹ measurements of achieved productivity should only be used to serve as a diagnostic measure to determine if the original parameters were in serious error. If not, productivity gains resulting from specific efforts that are then taken away undermines the "incentive" in incentive regulation. NERA further explains that regulatory accounting rules, when used to measure LEC profits, are inappropriate proxies for economic profit just as accounting earnings are an inappropriate measure of changes in economic profit.

In contrast, the method proposed by GTE for deriving the PCI will mimic the mechanism through which the competitive market captures productivity gains and passes them on to consumers. When a competitive firm introduces a productivity-enhancing innovation, it lowers its own costs relative to the industry average, on which the market price is based. For an interim period, the firm enjoys higher earnings as a reward for its innovation. As the rest of the industry adopts the innovation over time,

⁵⁹ See USTA's Comments in this proceeding, Attachment C.

the industry average cost is driven down, and price along with it. This passes the benefit of the innovation on to consumers.

The forecasting method proposed by GTE will predict the effect of this process in the next year, based on the past behavior of the PCI which in turn would incorporate information about industry TFP and input prices. Rather than arbitrarily attempt to "recapture" LEC earnings from prior years as AT&T's Historical Revenue Method will do, GTE's approach would limit LEC earnings, and pass the benefits of productivity gains to consumers, in much the same way a competitive market would do.

In summary: The Historical Revenue Method is a backward-looking calculation of the productivity factor that would have produced a specified rate of return. The Commission should not adopt this Model, which is contrary to the entire logic of price cap regulation.

VI. The Historical Price Method is not superior to the Christensen TFP approach. (Issue 2b)

Under economic theory, prices and quantities can be used to symmetrically calculate productivity growth, since both operate on the assumption that input values equal output values in each time period. The concern arises that, if yearly earnings vary during the historical period, a price-based productivity study could produce significantly different results than a quantities-based productivity study (the TFP method). As GTE stated *supra*, the goal of the PCI adjustment factor is to forecast what the LECs can achieve. Therefore, GTE submits that it is best to use actual measurements of quantities as opposed to price changes as a basis for estimating the productivity of the LECs. In its

analysis of the two methods, NERA also supports using a quantities-based method for the LECs as real price reductions are the result of productivity growth. Further, a direct (quantities) method, rather than an indirect (price change) method, best quantifies possible differences between the historical period and the future.⁶⁰

Further, the Commission is correct in its description (*Fourth Notice* at para. 85) of the Historical Price Method⁶¹ as a "cost-differential factor rather than a productivity factor."

As used by the Commission, the Historical Price Method relies on a specified rate of return for the LECs.⁶² TFP does not rely on a specified rate of return to determine a productivity factor. Rather, TFP relies on actual measurements of LEC inputs and outputs, uses actual indexes of cost and output, and does not have to infer what productivity was based on changes in prices.

In addition, as this Commission itself notes (*Fourth Notice* at para. 88), there are "problems with the reliability of the data" used in the Historical Price Method. As noted, the inclusion of WATS data beginning in 1986-87⁶³ and an inability to include special access because of a discontinuity in the time series makes the data used as a basis for

⁶⁰ *Id.*

⁶¹ The Commission refers to the Frentrup/Uretsky study for the years 1984-1990 as the Historical Price Method. *Fourth Notice* at para. 86.

⁶² "[U]nit costs for all time periods were calculated using a rate of return of 12.00 percent, the authorized rate of return at the time that the study was conducted. The rate of return was held constant over time in order to normalize the unit cost data for changes in the prescribed rate of return." *Fourth Notice* at para. 89.

⁶³ *Id.* at n.104.

the Historical Price Method a significant issue. TFP provides a more economically meaningful measurement of productivity than the Historical Price Method and should be adopted.⁶⁴

In summary: The goal of the PCI adjustment factor is to forecast what the LECs can achieve. Therefore, GTE submits that it is best to use actual measurements of quantities, as used in the Christensen TFP method, rather than price changes as a basis for estimating the productivity of the LECs.

VII. THE PCI ADJUSTMENT FACTOR SHOULD NOT INCLUDE A CONSUMER PRODUCTIVITY DIVIDEND. (Issue 2c)

In the *AT&T Further Notice*, the Commission introduced a CPD as an additive to the productivity factor during the transition to price caps to "stimulate carriers to generate productivity gains in excess of historical experience" and to create "significant

⁶⁴ It is vitally important that whatever method the Commission ultimately decides to adopt must be methodologically consistent and economically meaningful. The inclusion of the 1984 data point in the original Frentrup/Uretsky study and its subsequent omission in the updated study severely damages the credibility of the study used by the Commission. Arbitrary decisions to change the methodology employed, or the data sets used by the methodology, in order to obtain a specific result make it impossible for the LECs to make rational forward-looking business decisions. This Commission's acknowledgment that the 1984 data point was excluded because LECs' rates of return were higher than the previous Commission anticipated demonstrates the arbitrariness of the decision. See *Bell Atlantic Telephone Companies, et al. v. FCC*, Nos. 95-1217, et al., Brief for Respondents, dated October 13, 1995, p.36. It does not prove that the 1984 data point was a statistical outlier, only that its omission produced results more in line with this Commission's goal to restrict earnings.

downward pressure each year" on the price cap index.⁶⁵ In the *LEC Price Cap Order*, the Commission, similarly, added a 0.5 percent CPD to the productivity factor "to assure that the first benefits of price caps flow to customers in the form of reduced rates."⁶⁶ No CPD should be included in the price cap formula adopted in this proceeding. First, the value selected for the CPD was arbitrary, with no justification provided for how this value was derived.⁶⁷ Second, the Commission chose this mechanism to "assure the first benefits of price caps" were passed to customers. The industry is no longer in the "first" stage of price caps, hence this rationale has disappeared. Surely, the "first benefits" of price caps have been passed to customers during the five years the CPD was included in the productivity factor. Additional benefits will continue to be passed on, as the effect of the CPD has become embedded in the existing PCIs. Third, adoption of a methodology that forecasts the next year, as recommended by GTE, or, in the alternative, a methodology that includes only years under price cap regulation, would obviate the need to adjust for any perceived historical gains. The stated purpose of the productivity factor is to estimate achievable productivity gains.⁶⁸ There is no

⁶⁵ *Policy and Rules Concerning Rates for Dominant Carriers*, Further Notice of Proposed Rulemaking, CC Docket No. 87-313, 3 FCC Rcd 3195, 3407-08 (1988) ("*AT&T Further Notice*") (subsequent citations omitted).

⁶⁶ *LEC Price Cap Order*, 5 FCC Rcd at 6799.

⁶⁷ Agency decisions must be based on "facts [that] have some basis in the record." See *National Treasury Employees Union v. Horner*, 854 F.2d 490, 498 (D.C. Cir. 1988).

⁶⁸ *National Rural Telecom Ass'n v. FCC*, 988 F.2d 174, 183 (D.C. Cir. 1993).

evidence on the record that the LECs can continuously exceed historical productivity gains by 0.5 percent. Thus, there is no justification for adding a CPD.

In summary: GTE opposes the addition of a CPD to LEC productivity. First, the decision to add a CPD, and the value selected, were arbitrary. Second, a mechanism to pass the first benefits of price caps is no longer needed. Third, adoption of a methodology that forecasts the next year, as recommended by GTE or, in the alternative, a methodology that either includes only years under price cap regulation or more heavily weights years under price cap regulation obviates the need to adjust for any historical gains.

VIII. A SINGLE PCI ADJUSTMENT FACTOR SHOULD BE ESTABLISHED WITHOUT SHARING. (Issues 4 and 5)

The formula for the PCI adjustment factor supported by GTE is that which would prevail in a competitive market. In a single market, neither multiple prices nor multiple price changes for the same product can persist for very long. Arbitrage will eliminate all but random and unpredictable differences. These, by their very nature, do not persist. Since competition implies a single price in a market, this implies a single price change once a common price is charged. Thus, to mimic a competitive market, a single PCI adjustment factor should be employed. Further, in a well functioning competitive market, the rate of output price changes would not contain a sharing term. The Commission's inclusion of sharing distorts the price cap mechanism as a means of emulating a competitive market. Moreover, the inclusion of sharing makes the price cap mechanism mimic rate of return regulation.

As discussed in detail by the ICC, the use of a lagged industry average permits the preservation of the benefits of productivity over an extended period of time and provides both the incentive and opportunity to beat the average. Per the ICC, "the industry average is the only reasonable target" because "it is the only measure of productivity which converts the industry average ... input price index into an industry average output price index."⁶⁹ This rationale is equally applicable to the LEC industry.⁷⁰ A competitive market requires a constant effort to improve productivity.

GTE recognizes the Commission's concern that use of an industry average would allow the more efficient LECs to earn more than those that are less efficient. But, in fact, this is the way a competitive market functions. In a competitive market, firms must undertake actions to enhance productivity in order to improve their earnings and to maintain their status in that market. Those firms that do not take such actions will realize a decrease in earnings and, if unimproved, eventual exit from the marketplace. In

⁶⁹ Interstate Commerce Commission *Ex Parte* No. 290 (Sub-No. 4), Railroad Cost Recovery Procedures - Productivity Adjustment, decided March 22, 1989, at 453.

⁷⁰ The Commission should not draw the conclusion that the 5.3 percent X-Factor reflects achievable productivity based on the number of LECs selecting this factor for the interim period. The Commission correctly states (at para. 8) that GTE selected 4.0 percent for eight study areas and 5.3 percent for 38 study areas. Those 38 study areas represent less than fifty percent of GTE's rate base. Further, GTE selected the 5.3 percent option because the 1.3 percent incremental difference between 5.3 and 4.0 had less near-term harmful impact on GTE's earnings than the impact of sharing – not because it can be achieved. Further, if these factors were to have remained in place for more than one year, GTE would not have selected the 5.3 percent option for 38 study areas as the compounding effect of an offset this high is unsustainable.

addition, as the Commission notes (*Fourth Notice* at para.129), LECs have the ability under the existing rules to file tariffs for rate increases to prevent confiscatory rates.

GTE submits that, in setting the PCI adjustment factor equal to the industry average of LEC input price growth less LEC productivity growth without a sharing requirement, the Commission will establish a factor that will prompt all LECs to improve their efficiency. Those LECs that are performing above industry average will maintain an incentive to increase efficiency given that the benefits associated with increased efficiency can be retained. LECs at or below average will continue to strive to increase their efficiency. The overall result will be increased efficiency for the entire industry.

The key to increased industry efficiency is the ability to retain the earnings that result from achieving that increase. As the Commission rightly recognizes, "the sharing mechanism blunts the efficiency incentives created by the price cap formula."⁷¹ If the Commission wants to provide incentives for the LECs to achieve greater efficiency, then it must eliminate the sharing mechanism. The elimination of sharing is the only incentive that will produce the highest efficiency gains possible – which, in turn, will be reflected in the industry average TFP. Thus, the LECs' ongoing efficiency gains will be passed through to consumers.

Further, sharing perpetuates the link to rate of return regulation and all the "baggage" associated with that form of regulation; e.g., accounting conventions, jurisdictional separations, affiliate transaction rules, and depreciation prescriptions. These

⁷¹ *Fourth Notice* at para. 114.

items have nothing to do with the functioning of a competitive marketplace. Further, if the sharing mechanism is retained, it will interfere with other mechanisms the Commission is seeking to add to its price cap plan. In a parallel proceeding, the Commission has tentatively proposed a framework for selectively applying streamlined or nondominant regulation to access markets that meet competitive criteria.⁷² If sharing were to remain in place, it would create an undesirable rate of return link between markets which remain in price caps, and competitive markets which have been removed from price caps.

Sharing was instituted by the Commission as backstop mechanism for errors in its estimate of LEC productivity.⁷³ Since the record in this proceeding should provide ample evidence to substantiate the selection of a productivity factor that accurately predicts the LECs' productivity, sharing is no longer needed as a backstop mechanism. The Commission will have LEC pre- and post price cap productivity data available for analysis plus extensive documentation on productivity calculation methodologies. It is time to eliminate the sharing mechanism and allow the LEC price cap plan to truly emulate a competitive market.

In summary: GTE submits that the continued inclusion of sharing diminishes the coherence and effectiveness of price caps to a point where it becomes indistinguishable from rate of return regulation modified by factors forcing prices

⁷² The Commission addresses streamlined regulation in the *Second Notice* at paras. 127-51 and nondominant treatment at paras. 152-58. See, *D.94-1*, Second Further Notice of Proposed Rulemaking, CC Docket No. 94-1, FCC 95-393 (released September 20, 1995) ("*Second Notice*").

⁷³ See *First Report and Order* at para. 191.

downward. In contrast, the formula for the PCI adjustment factor supported by GTE is that which would prevail in a competitive market. Thus, to mimic a competitive market, a single PCI adjustment factor should be employed. Further, in a well-functioning competitive market, the rate of output price changes would not contain a sharing term. Inclusion of a sharing term distorts the price cap mechanism and prevents it from emulating a competitive market. The record of this proceeding will provide ample evidence to substantiate the selection of a productivity factor that accurately predicts the LECs' productivity. Therefore, a "backstop" mechanism is not needed.

IX. THE COMMISSION SHOULD ELIMINATE THE SEPARATE COMMON LINE FORMULA. (Issues 6a and 6c)

Since TFP is a direct measure of productivity where all inputs (labor, capital, materials) and all outputs (lines, minutes, etc.) are taken into account, a separate formula for the common line basket is not required. All changes in LEC productivity over time are captured regardless of whether they are driven by changes in minutes, lines, or any other output. If a TFP methodology is adopted, further adjusting the common line basket would result in "double counting" productivity gains because TFP growth uses lines and minutes as measures of output growth.⁷⁴

⁷⁴ A properly constructed productivity offset should reflect the entire range of diverse factors that cause changes in the unit cost of production for the LECs and should measure changes in the overall efficiency of production. Partial measures of productivity are inconsistent with the economics of price caps because they are confined to particular inputs or outputs. Therefore, GTE opposes the use of an interstate-only TFP methodology, as discussed *supra*,

All traffic sensitive services are marked by economies of scale as increased growth generates productivity gains. Thus, as more units of demand are carried on a LEC's network, an increase in productivity will be realized for all services, not just common line. Although the Commission concluded in the *First Report and Order* (10 FCC Rcd at 9078-9079) that LECs have little influence over common line usage growth,⁷⁵ this becomes irrelevant with the use of a TFP methodology. Neither who generates the demand nor which access service experiences the growth is relevant, since any growth in demand will be captured by the estimate of Total Factor Productivity. Once the productivity factor is set based on TFP, the benefits of demand growth at the long-term trend level for all services will be passed on to access customers. It makes no difference what the common line growth rate is or which entity is stimulating demand. TFP incorporates the effect of input growth for all services.

In summary: Adoption of a TFP methodology eliminates the need for a separate common line formula. TFP measures all inputs and outputs regardless of which party stimulates the demand. Further, the removal of the separate common line formula made possible by the adoption of TFP, eliminates the controversy over whether or not the formula should be based on a per-line or Balanced 50/50 formula.

⁷⁵ GTE does not agree with the Commission's conclusion. LEC access charge reductions (when passed through) do stimulate long distance calling which, in turn, results in increased access usage. Since divestiture, reductions in LEC access charges have more than explained the reductions in interexchange rates.

X. EXOGENOUS COSTS NOT INCLUDED IN THE PCI ADJUSTMENT FACTOR SHOULD STILL BE ALLOWED. (Issues 7a and 7b)

Exogenous cost changes should still be permitted under the price cap rules. Price caps are meant to mimic a competitive market where regulation does not require market participants to incur certain costs. Yet, price cap LECs are required to incur costs that would not be incurred if they were operating in a truly competitive market. As long as these costs uniquely affect price cap LECs and are not captured by the PCI adjustment factor, they should receive exogenous treatment.⁷⁶

In the *First Report and Order* (10 FCC Rcd at 9090-9091), the Commission established a third prong to its exogenous cost test, and now requires LECs to show that "their cash flows have changed due to the accounting cost changes." In addition, the Commission (*id.* at 9099) has determined that the issue of exogenous cost treatment must be addressed in a rulemaking proceeding or through a request for a waiver of the rules or a declaratory ruling. This provides the Commission the opportunity to determine if these costs are captured by the PCI adjustment factor. The Commission has made the exogenous test very strict; it should not further limit the ability of price cap LECs to seek such treatment. Until price cap LECs are allowed to operate in a fully competitive market where administrative, legislative, or judicial actions do not uniquely affect them, they should be allowed to seek exogenous treatment for costs incurred as a result of these actions if these costs are not accounted for in the PCI adjustment factor.

⁷⁶ Examples of costs that would not have been captured in the past are the amortization of inside wire and the reserve depreciation amortization.

In summary: To the extent that costs are not captured in the PCI adjustment factor, the Commission should rely on its existing rules to determine whether or not they qualify for exogenous treatment.

XI. THE TIMING OF A PERFORMANCE REVIEW IS DEPENDENT ON THE RULES ESTABLISHED BY THE COMMISSION IN THIS PROCEEDING. (Issue 8)

If the Commission adopts its tentative conclusions in the instant proceeding and (i) establishes a properly constructed PCI adjustment factor without sharing that is updated annually, (ii) adopts the pricing flexibility proposals in the *Second Notice*, and (iii) sets in place the criteria for streamlined regulation and nondominant treatment also proposed in the *Second Notice*,⁷⁷ the stage will be set for annual PCI adjustment factor updates and for services to be moved out of price caps – thereby negating the need for frequent reviews. The proceedings required to establish new values for the PCI adjustment factor have been extensive, and costly for both the Commission and the parties.

It is critical that the Commission structure the LEC price cap plan so that frequent reviews are unnecessary. All affected parties, not just price cap LECs, make major business decisions based on the Commission's rules, and frequent changes to these rules make it impossible to make sound business decisions. Moreover, if reviews occur too frequently, the system starts once again to mimic rate of return regulation. For the

⁷⁷ See *Second Notice* at paras. 127-158.

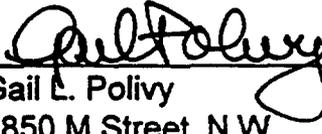
exchange carrier, a review every few years, which takes away earnings above a certain rate of return, would eliminate the incentive to improve productivity – which is at the heart of the price cap system, at the heart of "incentive" regulation.

In summary:GTE urges the Commission to structure the price cap plan in such a manner that frequent reviews are unnecessary. Not only would this action eliminate unnecessary time and effort by the Commission, the price cap LECs, and other participants, but it would allow all parties affected by the price cap plan to move ahead with decision-making processes that depend on this plan.

Respectfully submitted,

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THEIR ATTORNEYS

APPENDIX A

THE APPROPRIATE MEASURE FOR A PCI ADJUSTMENT FACTOR IS THE GROWTH OF LEC INPUT PRICES MINUS THE RATE OF GROWTH OF LEC TFP.

Under competition, a properly weighted index of output price changes equals the difference of a properly weighted index of input price changes minus the rate of change of total factor productivity.

Let $p_i(t)$ indicate output prices at time t , let $q_i(t)$ indicate output levels, let $w_i(t)$ indicate input prices and let $x_i(t)$ be input levels, and let

$$C(t) = C(q_1(t), \dots, q_I(t), w_1(t), \dots, w_J(t), t)$$

be a cost function depending on outputs, input prices, and time. In competition, there is a zero profit condition that total revenue equals total cost that holds identically; e.g.,

$$\sum_{i=1}^I p_i(t) q_i(t) \equiv C(q_1(t), \dots, q_I(t), w_1(t), \dots, w_J(t), t)$$

or

$$R(t) = C(t);$$

differentiating with respect to time gives:

$$\begin{aligned} \sum_{i=1}^I p_i(t) \dot{q}_i(t) + \dot{p}_i(t) q_i(t) &\equiv \sum_{i=1}^I C_i(q_1(t), \dots, q_I(t), w_1(t), \dots, w_J(t), t) \dot{q}_i(t) \\ &+ \sum_{j=1}^J C_j(q_1(t), \dots, q_I(t), w_1(t), \dots, w_J(t), t) \dot{w}_j(t) \\ &+ C_t(q_1(t), \dots, q_I(t), w_1(t), \dots, w_J(t), t) \end{aligned}$$

$$\begin{aligned}
R(t) \sum_{i=1}^I \frac{p_i(t) q_i(t) \dot{q}_i(t)}{R(t) q_i(t)} + \frac{\dot{p}_i(t) p_i(t) q_i(t)}{p_i(t) R(t)} &\equiv C(t) \sum_{i=1}^I \frac{C_i(q_1(t), \dots, q_I(t), w_1(t), \dots, w_J(t), t) q_i(t) \dot{q}_i(t)}{C(t) q_i(t)} \\
&+ C(t) \sum_{j=1}^J \frac{C_j(q_1(t), \dots, q_I(t), w_1(t), \dots, w_J(t), t) w_j(t) \dot{w}_j(t)}{C(t) w_j(t)} \\
&+ C(t) \frac{C_t(q_1(t), \dots, q_I(t), w_1(t), \dots, w_J(t), t)}{C(t)}
\end{aligned}$$

$$\begin{aligned}
\sum_{i=1}^I \frac{\dot{p}_i(t) p_i(t) q_i(t)}{p_i(t) R(t)} &= - \sum_{i=1}^I \frac{(p_i(t) - C_i(q_1(t), \dots, q_I(t), w_1(t), \dots, w_J(t), t)) q_i(t) \dot{q}_i(t)}{R(t) q_i(t)} \\
&+ \frac{C(t)}{R(t)} \sum_{j=1}^J \frac{C_j(q_1(t), \dots, q_I(t), w_1(t), \dots, w_J(t), t) w_j(t) \dot{w}_j(t)}{C(t) w_j(t)} \\
&+ \frac{C(t)}{R(t)} \frac{C_t(q_1(t), \dots, q_I(t), w_1(t), \dots, w_J(t), t)}{C(t)}
\end{aligned}$$

Under competition,

$$p_i(t) = C_i(q_1(t), \dots, q_I(t), w_1(t), \dots, w_J(t), t) \text{ and } R(t) = C(t) \text{ so}$$

$$\sum_{i=1}^I p_i(t) \frac{\dot{p}_i(t)}{p_i(t)} = \sum_{j=1}^J \sigma_j \frac{\dot{w}_j(t)}{w_j(t)} + \frac{C_t(q_1(t), \dots, q_I(t), w_1(t), \dots, w_J(t), t)}{C(t)}$$

which can be shown to be

$$\sum_{i=1}^I p_i(t) \frac{\dot{p}_i(t)}{p_i(t)} = \sum_{j=1}^J \sigma_j \frac{\dot{w}_j(t)}{w_j(t)} - \frac{TFP}{TFP}$$

To see this, note that if $F(y, x, t)$ is a distance function representing a technology, then the efficient netput pairs (y, x) satisfy $F(y, x, t) = 1$. Thus $F(y, x, t) \equiv 1$. Totally differentiating gives:

$$\frac{\partial F(y, x, t)}{\partial y} \dot{y} + \frac{\partial F(y, x, t)}{\partial x} \dot{x} + \frac{\partial F(y, x, t)}{\partial t} \dot{t} = 0$$

$$\frac{\partial F(y,x,t)}{\partial t} = -\left(\frac{\partial F(y,x,t)}{\partial y} \dot{y} + \frac{\partial F(y,x,t)}{\partial x} \dot{x}\right)$$

Also, by the envelope theorem, if

$$C(y, w, t) = \min\{x'w | F(y, x, t) = 0\}$$

then

$$\frac{\partial C(y,w,t)}{\partial t} = \lambda \frac{\partial F(y,x,t)}{\partial t}$$

Whereas profit maximization implies:

$$p_i = \lambda \frac{\partial F(y,x,t)}{\partial y_i}$$

$$w_j = \lambda \frac{\partial F(y,x,t)}{\partial x_j}$$

$$\begin{aligned} \frac{\partial C(y,w,t)}{\partial t} \frac{1}{C} &= -\frac{(p' \dot{y} + w' \dot{x})}{C} \\ &= -\frac{R}{C} \sum_{i=1}^I \frac{p_i y_i}{R} \frac{\dot{y}_i}{y_i} + \sum_{j=1}^J \frac{w_j x_j}{C} \frac{\dot{x}_j}{x_j} \\ &= -\frac{R}{C} \sum_{i=1}^I \rho_i \frac{\dot{y}_i}{y_i} + \sum_{j=1}^J \sigma_j \frac{\dot{x}_j}{x_j} \\ &= -\frac{TFP}{TFP} \end{aligned}$$

Where $\frac{R}{C} = 1$, on account of the zero profit condition.

APPENDIX B

THE EXISTING PRICE CAP FORMULA IS ONLY ECONOMICALLY VALID IF NO ADJUSTMENT IS MADE FOR THE W-FACTOR.

The *GDPPI-X+/-Z* formula, constructed as an approximation to the economically valid formula proposed by GTE, presupposes that the US input price change index grows at the same rate as the LEC price change index.

When the LEC input price index is unavailable, it may be approximated using the US industry input price index under the assumption that the two indices are the same – that is $\% \Delta W_{LEC} \approx \% \Delta W_{US}$. Christensen,¹ NERA,² and Duncan³ have presented evidence that indeed the two series are the same.

Lacking a specific US industry input price change index, this also can be approximated by solving:

$$\% \Delta P_{US} = \% \Delta W_{US} - \% \Delta TFP_{US}^4$$

to obtain:

$$\% \Delta W_{US} = \% \Delta P_{US} + \% \Delta TFP_{US}$$

Substituting this for the LEC input price change index gives the formula:

¹ See *Ex Parte* Affidavit of Dr. Laurits R. Christensen on Behalf of the United States Telephone Association, CC Docket No. 94-1, dated February 1, 1995.

² See USTA's Comments in the instant proceeding, Attachment C.

³ See *Duncan*, Testimony, pp. 5-10.

⁴ This is the theoretical relationship between the economy-wide price index, usually measured by changes in GDPPI, a hypothetical economy-wide input price change index, and the economy-wide TFP, published by the BLS.

$$\begin{aligned}
\% \Delta P_{LEC} &= \% \Delta W_{LEC} - \% \Delta TFP_{LEC} \\
&= [\% \Delta P_{US} + \% \Delta TFP_{US}] - \% \Delta TFP_{LEC} \\
&= \% \Delta P_{US} - [\% \Delta TFP_{LEC} - \% \Delta TFP_{US}] \\
&= \% \Delta P_{US} - X
\end{aligned}$$

Finally, $\% \Delta GDPPI$ is used to approximate $\% \Delta P_{US}$. The Z-Factor arises from consideration of other exogenous factors which, under competition, would cause output price changes and is simply added or subtracted as dictated by theory.

APPENDIX C

PROPERLY DONE, INCORPORATING A W-FACTOR REVERTS TO GTE'S PROPOSED METHOD, BUT WITH UNNECESSARY COMPLICATIONS THAT ALLOW THE POSSIBILITY OF GAMING.

In this appendix, GTE shows that, properly done, the $GDPPI-X+W+/-Z$ formula reverts to the method proposed by GTE – provided the averaging or prediction is done in a consistent fashion. If not done consistently; *i.e.*, if LEC TFP and input price series are measured using different methods than those employed for US TFP and input price series, the results will not be the same. Thus, employing a W-Factor to correct for possible differences in the US and the LEC input price series introduces a needless complication that may be manipulated to game the process. As discussed *supra*, when the LEC input price index is unavailable, it may be approximated using the US industry input price index to give the $GDPPI-X+/-Z$ formula, under the assumption that the two indices are the same – that is $\% \Delta W_{LEC} \cong \% \Delta W_{US}$. When they are not the same, a different derivation should be used. Assume here that:

$$\% \Delta W_{LEC} \cong \% \Delta W_{US} + W.$$

Using the same argument as in Appendix B,

$$\% \Delta W_{US} = \% \Delta P_{US} + \% \Delta TFP_{US}.$$

Substituting this for the LEC input price change index gives the formula:

$$\begin{aligned}\% \Delta P_{LEC} &= \% \Delta W_{LEC} - \% \Delta TFP_{LEC} \\ &= [\% \Delta GDPPI + \% \Delta TFP_{US} + W] - \% \Delta TFP_{LEC} \\ &= \% \Delta GDPPI - [\% \Delta TFP_{LEC} - \% \Delta TFP_{US}] + W \\ &= \% \Delta GDPPI - X + W\end{aligned}$$

Where again, $\% \Delta GDPPI$ is used to approximate $\% \Delta P_{US}$. A Z-Factor arising from consideration of other exogenous factors, which under competition would cause output price changes, is simply added or subtracted as dictated by theory and is not of concern here. Note that the first line in the formula is exactly what GTE proposes, whereas the last one is the proposed Commission formula with a W-Factor added.

Provided each component is calculated as required by theory, the two approaches should be the same. Consequently, the more complicated of the two should not be used. Further, in order to apply the model, the Commission must obtain estimates for each component in the formula. The formula based on an input price differential requires estimates of $\% \Delta P_{US}$ and $\% \Delta TFP_{US}$, for which the Commission uses GDPPI and a TFP estimate produced by the BLS. However, to the extent that the inputs in the model are not estimated in a consistent manner, the PCI adjustment derived will be biased. The direct method eliminates the need to estimate these components, and hence this source of error.

However, it must be noted that for the two methods to yield the same result, all of the terms in the formulas must be forecast in the same manner. What must be avoided at all costs is a piecemeal forecasting of the parts of the formula. For example, if the GDPPI is not averaged, the X-Factor is subject to a five-year moving average, while the

W-Factor is subject to a seven or ten-year moving average, then the methods will not yield identical results. Worries about the possibility of gaming the averaging process lead GTE to endorse the simplest method, while standing ready to support $GDPPI-X \pm Z$ if that proves easier to calculate and is more stable.

On the issues of gaming the averaging and stability, forecasting the PCI adjustment factor on the basis of past PCI adjustments, using optimal time-series' methods, removes the averaging process from gaming. Statistical tests exist to determine if the PCI is being optimally forecast or not. Indeed, such forecasts automatically remove the random component from the PCI that would cause instability; that is, they automatically smooth. Moreover, once the data are compiled and a new PCI adjustment is calculated from actual data, the forecast can be automatically updated. Such updates can be done quickly on modern personal computers. These latter three points apply to all three of the formulas.