

Case 2. Negative Residual

Table 4 below shows the case where the residual is negative. The correct weight for capital in the Performance-Based Model is .059, as shown in the upper panel of the table. In the PBM all costs and revenues are assigned to the appropriate inputs, and there is no residual from the total costs levied on ratepayers. The incorrect weight assigned by the Simplified Christensen Model, based on an assumed rather than actual return to capital, is shown in the lower panel of the table. In the SCM, part of the cost assigned to capital is not received by the LEC, and there is a negative 5.9 percent residual from the total costs levied on ratepayers. Thus, the Christensen Associates model weights the capital input, and hence the growth in capital input, too high. This produces an overstatement of the total factor input, and an overstatement in the growth in total factor input when capital growth is positive.⁷ Correspondingly, TFP and the growth in TFP – and consequently the X-Factor – are understated under the Christensen Associates approach. Understatement of the X-Factor leads to lower measured performance of the LEC. Use of the correct weight, however, would lead to a higher measured performance of the LEC: higher TFP and a higher X-Factor. But the actual profits to the LEC would be less than the assumed rate of return. Note that actual profits received by the LEC under the Christensen Associates assumed rate of return approach are lower than those credited in the cost measure that enters the price cap index formula. This characteristic of the SCM would force the LEC to *lose* in two ways: lower actual profits under the prevailing price cap, and a larger downward adjustment of the price cap at the end of the current period. Because the details

⁷ This is also subject to the conditions in the preceding footnote.

of the capital input and long-term user cost in the Christensen Associates model are not publicly available, it is not possible to compare directly Christensen Associates' assumed cost of capital and the actual capital cost levied on the ratepayers.

Table 4. SAMPLE CALCULATION OF COST SHARE WEIGHTS FOR NEGATIVE RESIDUAL				
<i>Performance-Based Model</i>				
Actual Capital Cost: $E_K = 50$				
$E_H = 450$	$E_M = 350$	$E_K = 50$	Actual Total Cost: $TC = 850$	
Labor Wt.	Materials Wt.	Capital Wt.	Remainder	Sum of Wts.
$E_H / TC = .529$	$E_M / TC = .412$	$E_K / TC = .059$	0	= 1
<i>Simplified Christensen Model</i>				
Actual Capital Cost: $E_K = 50$				
Assumed Capital Cost: $E_{KA} = 100$				
$E_H = 450$	$E_M = 350$	$E_{KA} = 100$	Actual Total Cost: $TC = 850$	
			Assumed Total Cost: $TC_A = 900$	
Labor Wt.	Materials Wt.	Capital Wt.	Remainder	Sum of Wts.
$E_H / TC = .529$	$E_M / TC = .412$	$AC_K / TC = .118$	-.059	= 1.059 (Total Cost Basis)
$E_H / TC_A = .50$	$E_H / TC_A = .40$	$E_H / TC_A = .10$	0	= 1 (Assumed Cost Basis)

From the above analysis of these two cases, the LECs are likely to advocate the Christensen Associates assumed rate of return approach used in the SCM, if they expect to earn a higher actual rate of return than that assumed in the SCM calculation of the X-Factor. Similarly, it is clear that an X-Factor computed from the actual performance-based rate of return, reflected in the PBM, is fairer to consumers and to the interexchange carriers simply because it reflects all the costs levied on them.

It appears from their reports to the FCC that the Case 2 situation does not describe the experience of the USTA local exchange carriers in the U.S. If it did, the results would be to under allocate costs and overstate TFP, which would clearly be disadvantageous to the price cap LECs. That Christensen Associates, on behalf of USTA, advocates an assumed rate-of-return method may be taken as indirect evidence that the profits of the RBOCs in particular are expected to be above, rather than below, the assumed rate of return. This conclusion is further supported by the inclusion of updated data concerning the year 1995, as developed by the Performance-Based Model.

C. Christensen Associates' Evasion of the Imperatives of Economic Theory

In its continued insistence that there is no necessary correspondence between revenues received by the LECs and the cost of inputs levied on ratepayers (which are authorized and enforced by the Commission), Christensen Associates repeatedly and calculatedly ignores two seminal and influential works in economic theory. These two works continue to govern best practice empirical measurement of productivity. The several effects of this correspondence -- of conforming to the

canons of economic theory -- are accounted for at lines 4, 6, and 7 in Table 1 of the Christensen Associates' critique.

The first such influential work is the paper by Jorgenson and Griliches, published in the *Review of Economic Studies* in 1967.⁸ This paper addresses the long-run relationship between inputs and outputs and asserts (with mathematical justification) the necessary equality between total revenues and total costs. It is the theoretical foundation for the later papers by Christensen and Jorgenson in the *Review of Income and Wealth* in 1969 and 1970.⁹ The second influential work is the paper by Berndt and Fuss in the *Journal of Econometrics* in 1986, where the measurement of total factor productivity in the short-run is demonstrated and the relationship between long-run and short-run measures is established.¹⁰ Once again, and for different reasons, the allocation of all revenues received by the enterprise to costs of the enterprise is shown to be necessary.

If Christensen Associates really wishes to refute the Performance-Based Model, which is explicitly based on the framework in the Berndt-Fuss paper, it must show the error in that paper. The readily observable fact is that Christensen Associates ignores the best practice literature, and

⁸ Jorgenson, D.W. and Griliches, Z. "The Explanation of Productivity Change," *Review of Economic Studies*, v.34(2) July 1967, pp. 249-280.

⁹ Christensen, L.R. and Jorgenson, D.W. "The Measurement of Real Capital Input", *Review of Income and Wealth*, Series 15, No. 4, December 1969, pp. 293-320, and "U.S. Real Product and Real Factor Input, 1929-1967" *Review of Income and Wealth*, Series 16, No. 1, March 1970, pp. 19-50.

¹⁰ Berndt, E.R. and Fuss, M.A. "Productivity Measurement with Adjustments for Capacity Utilization and Other Forms of Temporary Equilibrium," *Journal of Econometrics*, v. 33 no. 1/2, October/November 1986, pp. 7-29.

continues the practice of measuring productivity by invalid methods. Christensen Associates assertedly bases its model on a long-run framework, wherein an amount less than the total of received revenues is typically assigned to the costs of the LECs in the calculation of TFP.

Finally, in its measurement of output in interstate access services, and in its assertion that gain-sharing is unnecessary to the working of LEC price cap regulation, Christensen Associates ignores the definitive work on incentive regulation by Laffont and Tirole, in which two key principles are established: First, the basic principle of the price cap form of incentive regulation is shown to require the assumption that the regulator does not know the costs of the regulated enterprise in sufficient detail to set prices that will result in the best allocation of resources to the production of the regulated good or service.¹¹ This principle requires the regulator to take the perspective that output of the regulated enterprise is defined from the perspective of its customers, which leads immediately to the premise of the Performance-Based Model that interstate access services are priced on a per minute basis, the basis on which interstate charges are assessed. The second crucial principle of the theory of price cap regulation, as shown by Laffont and Tirole, is that the enterprise must have an economic incentive to reveal -- if only approximately --- its cost structure. That incentive consists in sharing the gains from cost reduction with the ratepayers in the form of reduced charges for its services.¹² Without the sharing provision, the regulated firm will seek to overstate its costs and reap the rewards of higher rates. This practice results from the fact that the firm has more information

¹¹ Laffont, T.-J. and Tirole, J. *A Theory of Incentives in Procurement and Regulation*, MIT Press, 1993, see especially pp. 155-158.

¹² Laffont and Tirole, pp. 18-19 and elsewhere.

about its costs than does the regulator, and is the core justification for incentive regulation, specifically price cap regulation. The fact that Christensen Associates and USTA take the position that price cap-based incentive regulation should be pursued without the incentive provided by sharing the gains with ratepayers is consistent with the principle that the regulated firm will seek to advance its own interests. This assertion is not to be taken at face value, however. Specifically, the LECs' selections of higher X-Factor targets are clear evidence that the cost of interstate access are lower than reported, and that price cap incentive regulation based on gain-sharing has worked. Once again, if Christensen Associates wishes its model to be taken seriously, it must deal with the model's apparent violation of the principles of price cap regulation as stated in the literature.

In its effort to cloud the issues noted above, Christensen Associates has made detailed criticisms of the Performance-Based Model, characterizing that model's conformance with the best practices of TFP measurement, in the context of price cap incentive regulation as "errors". This observation applies specifically to Christensen Associates' critique of the measurement of interstate output in terms of minutes rather than lines,¹³ as well as its criticism of the extrapolations of data to implement that measurement.¹⁴ These effects are illustrated in Exhibit 3, p. 27, of its critique. Based upon inquiries of data archivists at the FCC, AT&T and elsewhere, data do not in fact exist, continuously for the 1984-1995 period, for a number of variables now reported in ARMIS and used in the PBM. Christensen Associates may recall that when it reported TFP for the period 1984-1992, it used extrapolative methods similar to those it now criticizes. These methods were used by

¹³ Christensen Associates, pp. 8-17.

¹⁴ Christensen Associates, pp. 25-26.

Christensen Associates to extend the data back into the period before the accounting and reporting changes mandated by the FCC in 1988. Christensen Associates also criticized the use in the PBM of an input price index from the Bureau of Labor Statistics' input-output study of the U.S. economy. It claims that the BLS data do not reflect the materials input purchases of the LECs, and it accounts for this in line 10, Table 1 and line 5, Table 2.¹⁵ There is no doubt that the price index is not ideal, as pointed out in AT&T's comments. However, it does represent an adaptation of publicly available data for the purpose of measuring inputs for the LECs. Christensen Associates does not make such an effort, but instead selects the GDP deflator to use as its deflator for materials. Moreover, the sources cited by Christensen Associates do not suffice to construct a materials price index. It is surprising that Christensen Associates would even raise this issue in light of its own questionable selection of a price index for materials. Further confusion concerning price indexes is sown by Christensen Associates' assertion that it constructs detailed price indexes to deflate interstate output, and that these indexes are superior to the PBM's use of quantities to deflate revenues to obtain prices.¹⁶ The claim to have deflated revenues based on price indexes alone is not borne out by Christensen Associates' earlier worksheets (covering the years through 1993) that have been made available to us. If a new methodology has been introduced in Christensen Associates' model, we are unaware of it.

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Finally, Christensen Associates criticizes the focus of the Performance-Based Model on the RBOCs. The small effect of that criticism is accounted for at line 12 of Table 1 and line 7 of

¹⁵ Christensen Associates, pp. 20-23.

¹⁶ Christensen Associates, p. 10.

Table 2. This minimal impact plainly justifies the omission of other (non-RBOC) LECs, in light of the considerable additional effort that would have been required to carry out a broader analysis. Such a broader study would have little probable effect, partially because some of the data required for that task were not available for some of these other LECs in several reporting years. Indeed, the effect is shown to be zero on the output side of the accounting for the 1989-94 period, which appears inconsistent with the 0.1% effect attributed on the price side of Christensen Associates' analysis in Table 2. Once again, we look forward to determine the effect for ourselves, and to validate Christensen Associates' results, when we have an opportunity to review its data and spreadsheet methods, after its supporting data and work papers are received pursuant to AT&T's request. It is also curious that several of the effects on the quantity side of Christensen Associates' analysis have no corresponding effect on the price side, as the dual nature of measurement in the theory of production would suggest.

D. Presentation of New Data Reflecting Results for the Year 1995

In light of the availability of more recent data, the Performance-Based Model has been updated for 1995. Specifically, the PBM results have been revised to include data from ARMIS reports for calendar year 1995. The recent level of improved performance by the LECs raises the X-Factor average for the LECs' interstate access services during the 1985-1995 period to 8.51 percent. The LECs' total regulated company X-Factor increased to 6.20 percent for the 1985-1995 period.

These results are shown below. Table 5 presents the results for 1985-1995, based on the recent ARMIS data reported by the LECs.¹⁷

Table 5. TFP, Input Price Differential and X-Factor in Interstate and All LEC Regulated Services: Rates of Growth, 1985-1995		
(Total: 7 RBOCs)		
	Interstate Access Services	All LEC Regulated Services
Output Growth	7.92%	5.61%
- Input Growth	1.59%	1.59%
= TFP Growth LECs	6.33%	4.03%
Input prices: GDPPI	3.06%	3.06%
- Input prices: LECs	0.72%	0.72%
= Input Price Differential (IPD)	2.35%	2.35%
- TFP Gr in NFB	0.18%	0.18%
= X-Factor	8.51%	6.20%
Note: TFP Gr in NFB is Total Factor Productivity Growth in Non-Farm Business		
Source: Computed in Performance-Based Model		

¹⁷ The underlying spreadsheets on which these results are calculated are, of course, available to the Commission Staff.

1. **Brief Comments on Implications of TFP and X-Factor Results Extended Through 1995**

- The performance results shown in Table 5 above strongly support the benefits to consumers arising from the Commission's use of incentive regulation for the LECs. It is notable that these results were achieved in a period when five of the seven RBOCs had elected the highest X-Factor in their price cap formula, and thus were not required to share gains above their targeted growth rates.

- The strong recent productivity performance of the LECs is consistent with the rising stock prices noted in AT&T's presentation to the FCC Staff in April 1996. This level of performance shows that *both ratepayers and investors* benefit from gain-sharing incentive regulation.

- The LECs' interstate productivity performance for 1995 exceeded the estimate for all LEC regulated services by more than three percentage points. This further supports AT&T's contention that the interstate TFP for the LECs has been growing substantially faster than their productivity for all the LECs' regulated services.

- The LECs' TFP performance in 1995 also establishes unequivocally AT&T's previous showing, in its Comments in the X-Factor proceeding, that the LECs

continue to have substantial as-yet-unexploited potential for productivity growth and cost reductions.

- The 1995 results reflected in Table 5 provide strong evidence of the LECs' economies of scale for their interstate access services.
- The Input Price Differential for the 1985-1995 period is measured at 2.35 percent annually. This again confirms the FCC Staff (Bush-Uretsky) findings -- supported by AT&T's analysis -- that the IPD is an important factor and should be recognized in measuring the X-Factor, despite year-to-year variations in the IPD.

2. Brief Review of Methodology for Updated Results

The results presented in Table 5 above were computed in accordance with the general procedures of the Performance-Based Model, described in detail in AT&T's Comments and attachments submitted in the X-Factor proceeding. Similar methods were used in calculating the updated TFP growth and X-Factor for the 1985-1995 period (Table 5), with a modification of depreciation included in the model and thus in its treatment of capital. Stated below is a brief review of some other aspects of the procedures followed in the 1995 update of the PBM.

- In the absence of 1995 data from the U.S. Bureau of Labor Statistics, the average rate of TFP growth for the non-farm business sector was extrapolated

to 1995 based on the earlier growth rate, 0.18 percent per year, for 1985-94. The average rate of input price growth was extrapolated in the same way (3.06 percent per year) applied to 1995.

- The growth rates for the components of interstate access and total regulated services output were extended based on their 1994-1995 growth rates reported in ARMIS.
- Capital, labor, and materials inputs for the LECs for 1995 were computed in the same manner described for the PBM as in the Staff presentation of April 1996, except that depreciation is now that which is conveyed to ARMIS in the 4302 report. This modification meets the point raised in the Christensen Associates' critique (p. 19) and reflected (partially) at line 9 of Table 1 and (partially) at line 6 of Table 2 of that critique.
- The growth rates of interstate inputs were taken to be the same as for all LEC regulated services. This is a conservative practice, as shown in the Reply Comments of AT&T and the attached Statements of Norsworthy, Berndt and Nadiri, submitted in the X-Factor proceeding (CC Docket No. 94-1) on March 1, 1996. Taken together with the growth in the output for interstate services, the PBM produced a TFP growth of 12.5 percent in the year 1995 for the LECs' interstate access services.

E. Concluding Comments

The Christensen Associates' critique of the Performance-Based Model is unfounded. That critique is based largely on the calculations and data derived from the Simplified Christensen Model, and it is really an investigation of the sensitivity of the SCM to the assumptions in the PBM. This is especially troubling because, in addition to the methodological differences between the two models, the SCM examines only the period from 1988 forward, while the PBM examines the period 1985-1995, the entire time frame recognized as appropriate by the Commission for assessing the performance of the LECs. Because 1985-1987 was a period of greater than average productivity growth (for the whole period), one may legitimately inquire why it has been willfully omitted in the analysis by Christensen Associates. Further, the effects of the PBM assumptions are necessarily magnified, when applied on the basis of the five-year span of the SCM, compared to the 10- or 11-year span of the PBM. This is true because most of the effects of the PBM assumptions are to increase productivity growth measured in the SCM, which is based on a period of overall slower growth. It is also instructive to note that, in the updated PBM results, the inclusion of data for 1995, when productivity growth of the LECs spurted, produced an even higher TFP growth for the LECs' interstate access.

The bulk of the discrepancies in the results for the PBM and the SCM relates to some critical differences in their basic approaches. The PBM properly measures TFP growth for the LECs' interstate access services on the basis of reasonable approximations of TFP for interstate services only. In contrast, the SCM relies on the invalid assumption that TFP measured for all LEC regulated

services is the equivalent of TFP for LEC interstate services separately -- an assumption that produces a substantial downward bias in the SCM estimates of the X-Factor. The PBM determines capital input based on the actual performance of the LECs, whereas the SCM computes its capital input based on an assumed rate of return for the LECs, premised on the questionable theory that their capital is continuously adjusted to cost-minimizing levels. Finally, the X-Factor calculation advocated by Christensen Associates completely leaves out recognition of the Input Price Differential -- an omission that is manifestly improper and results in a substantial understatement of the X-Factor produced by the SCM.

Christensen Associates' critique further ignores the theory of price cap regulation. Such incentive regulation is based on the assumptions that the LECs know their expected costs better than do the regulators, and that incentives are required to prompt the LECs to make customer-oriented rate reductions. In effect, Christensen Associates advocates incentive regulation without incentives.

When the requirements of modern TFP measurement, regulatory theory and practice, and common sense are taken into account, the effect of the Christensen Associates' critique is to show how closely the models' results would resemble each other if their calculations used the same basic assumptions. Labeling these differences as "errors" does not make them so, even if Christensen Associates chooses to brand them as such. Again, the LECs' own choices of X-Factor targets loudly assert that price cap regulation is working, and confirm the fact that actual and expected LEC performances far exceed the results produced by the model created by Christensen Associates.

II. RESPONSE TO STRATEGIC POLICY RESEARCH

At page 25 of its paper,¹⁸ Strategic Policy Research ("SPR") contends in its analysis of the asserted LEC depreciation "shortfall" that the 4.77 per year quality adjustment, set forth in the Norsworthy Statement of January 1996 (misstated as "January 1995" by SPR) in Docket 94-1, should be construed as additive to depreciation. SPR's interpretation is incorrect.

My quality adjustment, as stated in its original form¹⁹ and in my Statement attached to the Comments of AT&T in Docket 94-1,²⁰ applies to the net book value of capital for 11 LECs for the period 1981-1990. That adjustment includes not only the effects of quality change, but also reflects the corrections for such erroneous depreciation, positive or negative, that may occur in the net stock series, and for capacity utilization as well.

The quality adjustment factor is developed as a modifier to the net stock of LEC capital input measured as book value. That is, the unadjusted capital stock, K_u , is adjusted by a multiplying factor q that is based on the marginal product of the capital in an econometric model of production. The factor q is expressed as a function of the characteristics of the capital input, z_1 , that

¹⁸ Attachment 15, USTA Comments, CC Docket No. 96-262, January 29, 1997.

¹⁹ **Measurement of Productivity and Marginal Costs for Incentive Regulation of Telecommunication Services**, John R. Norsworthy, Show-Ling Jang, James C. MacDonald, Diana H. Tsai, Cecile W. Fu, and Yi Jing. Report to the New York State Public Service Commission, Center for Science and Technology Policy, School of Management, Rensselaer Polytechnic Institute, 1993.

²⁰ **Analysis of TFP Methods for Measuring the X-Factor of the Local Exchange Carriers' Interstate Access Services**, Statement of Dr. John R. Norsworthy, Appendix A, Comments of AT&T, CC Docket 94-1, January 11, 1996.

are relevant to its performance in producing telephone services. Weights for the characteristics (a_1 in equation (1) below) are determined in the process of estimating the model of production. The adjusted capital input results from multiplying the unadjusted input by the quality factor q .

$$K_A = K_U \cdot q(\sum_1 a_1 z_1) \quad (1)$$

In the study of 11 large LECs, we specified the characteristics of the capital stock as the number of central office switches of several types: programmable digital and analog switches, and switches of earlier technology. For interoffice transmission equipment, the characteristics are miles of fiber cable and miles of copper cable.

For the use that we made of the quality factor, adjusting the current dollar value of the net stock for changes in its composition, this way of describing the stock is appropriate. The quality factor may also capture effects that are correlated through time with the characteristics used to describe the capital stock. These other factors make the resulting quality adjustment factor inappropriate to use as an addition to conventional accounting depreciation, as SPR does at pages 25-26 of its analysis. Specifically, the different RBOCs added large programmable digital central office switches (e.g., SS-7s) in the mid-1980s to permit equal access to long distance carriers. The LECs began the post-divestiture period with different proportions of the large switches, and acquired them at different rates. To the extent that the more capable switches were underutilized immediately after their installation, the estimated quality factor would include adjustment for underutilization of the switching capacity. Similarly, to the extent that the new equipment is allowed to be depreciated

too slowly or too rapidly by the accounting rules of the Commission, that effect would also be captured in the estimated quality adjustment factor.

These adjustments are desirable in a quality factor designed to take account of any factors associated with the composition of the capital stock that affect its performance, its marginal product in producing telephone services. However, the adjustments do not permit the quality factor to be interpreted as an add-on to conventional depreciation. Because of the likely biases from misspecified depreciation and capacity utilization, *inter alia*, the annual quality adjustment rate of 4.77 percent is entirely inappropriate for adding to depreciation. In particular, such an interpretation would misspecify an increase in excess capacity as depreciation cost, an entirely incorrect use of the quality adjustment. Such use would give an upward bias to economic depreciation as measured by SPR.

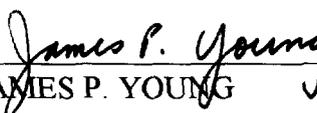
In AT&T's subsequent modification of the Performance-Based Model, the quality adjustment was eliminated and replaced by a perpetual inventory calculation of the capital stock. This procedure, on balance, is more appropriate, in part because the quality factor from the study of the 11 large LECs covered the period from 1981 to 1990, overlapping in part the pre-divestiture period, and excluding the years since 1990.²¹ Thus, the Performance-Based Model has been improved by

²¹ See Reply Statement of Dr. John R. Norsworthy and Dr. Ernst R. Berndt, Response to Comments of Local Exchange Carriers on Methods for Measuring the X-Factor for their Interstate Access Services, Appendix B to Reply Comments of AT&T, CC Docket No. 94-1, Price Cap Performance Review of Local Exchange Carriers, March 1, 1996.

dropping the quality adjustment based on the earlier study of 11 large LECs. Accordingly, the use of this factor by Strategic Policy Research is incorrect.

CERTIFICATE OF SERVICE

I, James P. Young, do hereby certify that on this 18th day of February, 1997, a copy of the foregoing corrected "Reply Comments of AT&T Corp." was mailed by U.S. first class mail, postage prepaid, to the parties on the attached Service List.



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