Table A1. Rate of Return and User Cost (Rental Price) of Capital, Consistent with Financial Theory and Other Variants: Continental Airlines, 1972-1986

Rate of Return

	r_F	r_{noF}	PI	δ	$p_{A,T}$	$p_{A,T-1}$	A_{T-1}	$p_{F,T}$	$p_{F,T-1}$	F_{T-1}	F_T/A_T
					0.37	0.37		2.25876	2.38068		0.24288
1972	-0.1009	-0.1867	126.61	0.18333	0.39	0.37	1366.93	2.15424	2.25876	349.91	0.28071
1973	-0.1886	-0.3887	39.20	0.18333	0.39	0.39	1363.20	2.02906	2.15424	378.59	0.40316
1974	-0.1629	-0.3443	-19.99	0.18333	0.46	0.39	1251.55	1.86637	2.02906	531.61	0.27587
1975	-0.1836	-0.2848	29.95	0.18333	0.49	0.46	1485.00	1.70325	1.86637	383.00	0.30732
1976	-0.1218	-0.1901	36.04	0.18333	0.55	0.49	1377.16	1.60229	1.70325	432.53	0.35106
1977	-0.183	-0.2962	-45.80	0.18333	0.60	0.55	1540.05	1.49911	1.60229	508.32	0.69068
1978	-0.0414	0.01194	171.21	0.18333	0.65	0.60	1192.80	1.38972	1.49911	808.99	0.81487
1979	0.0358	0.23907	294.87	0.18333	0.71	0.65	1050.35	1.27744	1.38972	856.51	0.84615
1980	0.06687	0.29855	313.03	0.18333	0.80	0.71	1044.44	1.16876	1.27744	882.66	0.60544
1981	0.23812	0.51782	615.27	0.18333	0.93	0.80	1289.49	1.0621	1.16876	752.35	0.41179
1982	0.0129	0.04514	486.04	0.18333	1.00	0.93	3238.39	1	1.0621	1273.92	0.53982
1983	0.05873	0.11055	499.17	0.18333	1.11	1.00	2685.33	0.96101	1	1424.15	0.70201
1984	-0.0522	-0.0576	138.73	0.18333	1.17	1.11	2370.67	0.91987	0.96101	1562.95	1.06817
1985	-0.0624	-0.0853	68.42	0.18333	1.22	1.17	1816.93	0.88771	0.91987	1921.80	0.64777
1986	-0.3664	-0.5272	-881.50	0.18333	1.27	1.22	1727.85	0.86481	0.88771	1115.88	0.97457
Avg	**-0.0377**	**0.00607**	**154.133**	**0.18333**	**0.90936**	**0.83864**	**1757.59**	**1.14844**	**1.22466**	**1049.1**	**0.69567**
St Dev	***0.15536***	***0.28996***									
Coef Va	-4.1197	47.7685									

User Cost of Capital

	p_T	p_{TnoF}	$p_{Tno,\varepsilon}$	$p_{TnoF,\varepsilon}$	*taxfactor*	*taxfactor no equity*	μ_T	z_I	λ_T	ε_T	τ_T	*Equity*	*Debt*	RoE	RoEnoF
1972	-0.0927	-0.0566	-0.1607	-0.0996	0.6136	1.0365	0.5114	0.8705	0.04839	0.34151	0.0149	228.56	440.71	-0.5709	-0.4109
1973	0.00308	-0.0432	0.00111	-0.0794	0.59327	1.03191	0.51	0.8705	0.05041	0.28965	0.0146	212.86	522.02	-1.1934	-0.9707
1974	-0.0192	-0.0603	-0.0393	-0.1128	0.57588	1.03039	0.5118	0.8705	0.05144	0.24713	0.0137	190.87	581.49	-1.3403	-0.8872
1975	-0.0078	-0.0318	-0.0204	-0.0659	0.51805	0.98264	0.514	0.8705	0.075	0.15206	0.0126	130.94	730.17	-1.9533	-1.4762
1976	-0.0041	-0.0204	-0.015	-0.0478	0.48695	0.97974	0.5151	0.8573	0.08333	0.04736	0.0121	49.87	1003.20	-3.4483	-2.5727
1977	-0.0126	-0.0437	-0.0319	-0.0934	0.49565	0.98007	0.5164	0.8573	0.08333	0.08475	0.0118	98.80	1066.91	-3.0884	-2.5575
1978	0.02999	0.04557	0.05334	0.08481	0.48495	0.97933	0.5135	0.8573	0.08333	0.03414	0.0109	41.13	1163.58	-1.9427	0.20882
1979	0.05411	0.11968	0.09963	0.22845	0.49621	0.97498	0.4955	0.8573	0.08333	0.01762	0.0098	23.15	1290.87	2.8965	7.05063
1980	0.05672	0.13761	0.10478	0.26485	0.49312	0.97583	0.4991	0.8573	0.08333	0.01761	0.0095	26.44	1475.47	4.72098	8.34857
1981	0.12742	0.239	0.23396	0.44576	0.4968	0.94299	0.5017	0.8573	0.1	0.10795	0.0095	398.38	3292.02	1.14447	1.34588
1982	0.07788	0.09493	0.14707	0.18128	0.57187	1.14722	0.5078	0.8573	0	0.0248	0.0091	94.87	3729.94	0.59132	1.42527
1983	0.0981	0.12775	0.18649	0.24591	0.57208	1.14652	0.5066	0.8573	0	0.02205	0.0091	86.73	3846.89	2.78261	3.42283
1984	0.06649	0.06305	0.12082	0.11399	0.57647	1.14564	0.5051	0.8573	0	0.0326	0.0098	130.82	3882.11	-1.6479	-1.1564
1985	0.09882	0.07648	0.13106	0.10042	0.83623	1.14687	0.5072	0.8573	0	0.63907	0.0099	2066.07	1166.87	-0.1176	-0.0877
1986	-0.2083	-0.3708	-0.2799	-0.4949	0.83169	1.10104	0.5084	0.9023	0	0.68685	0.01	2122.84	967.84	-0.5334	-0.5213
Avg	**0.02563**	**0.03128**	**0.05002**	**0.06863**	**0.4228**	**0.76802**	**0.37176**	**0.63169**	**0.03444**	**0.11432**	**0.00743**	**342.608**	**1525.71**	**0.0905**	**0.99376**
St Dev	***0.09127***	***0.15729***	***0.13967***	***0.24582***											
Coef Va	3.56061	5.02785	2.7922	3.58196											

[1] Fraumeni and Jorgenson (1980) pp. 9-250, particularly appendix B.

[2] Oddly, the published version includes only financial *working* capital.

[3] The lowest level of aggregation for which the NIPA provide financial accounts is nonfinancial corporations in the private business sector. See Triplett (1991, 1992), and *System of National Accounts, 1993*, especially Chapter VI, The Production Account, pp. 121-156 and Chapter XI, The Financial Account, pp. 241-262.

[4] In Jorgenson and Yun (1991), the rental price of capital is developed in a framework that incorporates the return on equity, and that moves closer to the theory of finance.

[5] Tax parameters are taken from Jorgenson and Yun (1991).

[6] This section largely follows the Jorgenson development stream as instanced in note 2 above.

[7] Jorgenson et al. (1987, p. 123) also include an adjustment for the 1962-1963 tax credit. It is omitted here because that form of the tax credit has not been reenacted.

[8] Here and hereafter, the notation follows Jorgenson et al. (1987), pp. 122-23.

[9] Jorgenson et al. (1987) p. 122.

[10] Demonstration of the substitution bias and biases in measures of economies of scale, total factor productivity and its growth, capacity utilization and the shadow cost of capital are shown in the appendix to be provided later.

[11] The data were assembled and reported in Pitt (1991).

APPENDIX B

Statement of Dr. John R. Norsworthy

RESPONSES TO ISSUES FOR COMMENT

In its Fourth Further Notice of Proposed Rulemaking in CC Docket No. 94-1 ("Fourth Further Notice"), the Commission seeks comments on the following matters regarding the long-term LEC price cap plan:

a. Calculation of the X-Factor;

b. Whether the X-Factor should be reviewed and modified periodically or set on a permanent basis;

c. The number of X-Factors to be included in the plan;

d. Sharing requirements, if any, to be associated with each X-Factor;

e. The common line formula;

f. Exogenous cost rules; and

g. Rescheduling of the LECs' price cap performance review.

Also, the Commission has requested comments in this rulemaking proceeding addressed to certain matters raised in the Second Further Notice of Proposed Rulemaking in CC Docket No. 94-1 (Issues 19 and 20, paras. 159-172) ("Second Further Notice") that relate to the X-Factor and sharing issues being considered here.

In responding to the issues requested for comment, I have taken into account the Commission's "General Criteria" for establishing the X-Factor in the LECs' price cap plan. As the Commission stated (Fourth Further Notice, paras. 16-21), the X-Factor adopted for the LECs should embody the following three essential characteristics:

1. The X-Factor must be economically relevant, i.e., it should provide a reliable measure of the extent to which changes in LECs' unit costs have been below the general level of inflation.

2. The X-Factor should ensure that ongoing gains by the LECs in reducing unit costs are passed through to consumers.

3. The calculation of the X-Factor should be reasonably simple and based on accessible and verifiable data.

I agree fully with these criteria, and have endeavored to follow them in our development and implementation of the Performance-Based Model for measuring the TFP and the X-Factor for the LECs' interstate access services (described in my Statement in Appendix A).

In the remainder of this Statement, I will give my responses and comments concerning the issues specified in the Commission's Fourth and Second Further Notices. I will refer to each issue in the Fourth Notice by its number and page number, and present my response thereafter. In addition, I will respond to the other issues requested for comment in this proceeding that were designated in the Second Further Notice. These responses will appear in the last section of this Statement.

1: X-FACTOR METHODOLOGY

Total Factor Productivity (TFP) Approach

Issue 1a (p. 13)

> What is the most reasonable method to develop output price indices for TFP calculation purposes? What data sources should be used to develop output price indices?

Response/Comments

The organizing principle for productivity analysis of an enterprise that provides services to a market is that the output measures should reflect the quantities of services that are chosen by the customers, and the prices that the customers face when deciding what quantities of services to buy. For implementation in practice, the output measures must match the available revenue data sources reasonably well and must be sufficiently compact to be manageable. When these principles are applied to productivity measurement for the LECs, the output measures available through the ARMIS reports that most accurately capture the decisions of the customers are minutes of interstate access, supplemented by interstate and special access lines; minutes of intrastate toll calls; and the number of local calls. The corresponding revenues from the same source are interstate access revenues, intrastate toll revenues, and local revenues.

As noted in Appendix A, aggregated interstate access services provided by the LECs have grown more rapidly than local service and intrastate toll service. Table 1, reproduced below, shows rates of growth for three categories of telephone service for the 1985-1994 period.

Table 1: Rates of Growth of Telephone Services ALL RBOCs, 1985-1994				
Year	**Fisher Ideal Quantity Index: Interstate Access**	**Local Service: Number of Calls**	**Intrastate Toll: Minutes of Use**	**Fisher Ideal Quantity Index: Local and Interstate**
1985	1.000	1.000	1.000	1.000
1986	1.070	1.012	1.037	1.020
1987	1.152	1.019	1.094	1.043
1988	1.258	1.067	1.166	1.098
1989	1.374	1.105	1.267	1.156
1990	1.489	1.146	1.399	1.224
1991	1.573	1.182	1.500	1.278
1992	1.651	1.223	1.552	1.322
1993	1.741	1.262	1.683	1.385
1994	1.849	1.314	1.840	1.463
Growth for Period	**6.83%**	**3.03%**	**6.78%**	**4.22%**

1985 = 1.000
Source: Computed in Performance-Based TFP Model from data in BOC reports to FCC

These measures of activity represent the services provided by the LECs better than the categories of deflated revenues in the USTA model. The three categories of service in the Performance-Based Model are priced differently. Interstate access services are sold principally to the Interexchange Carriers (IXCs). Intrastate access and toll services are regulated by state authorities and are sold primarily to IXCs and end users of telephone services. Minutes of use for interstate and intrastate toll services are traffic-sensitive, as

are the charges assessed for these services. Minutes of use measures are more traffic-sensitive than deflated toll revenues used in the USTA model, and thus more accurately reflect the decisions of telephone customers.

As Table 1 shows, interstate access services have grown at an annual rate of 6.83 percent; the LECs' other regulated services, local and intrastate, have grown at annual rates of 3.03 percent, and 6.78 percent, respectively. When the last two outputs are combined into a single Fisher Ideal Quantity Index [1] based on their revenues, the rate of growth is 4.22 percent per year.

Output price and quantity indices should be constructed using the **Fisher Ideal Index** (FII) method. This is the method recommended by Diewert (1993), who is widely acknowledged to be the foremost authority on index numbers in the economics profession. The FII method, unlike the **Tornquist Index** method used in the USTA model, can accommodate the introduction or disappearance of services during the period covered by the index. The FII method also gives the same result for TFP growth when the computations are constructed from price and from quantity indices. The Tornquist Index gives different results when computed from price and from quantity indices. Both index

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1 W.E. Diewert, "Fisher Ideal Output, Input and Productivity Indexes Revisited," Chapter 13 in W. E. Diewert and A. O. Nakamura, ed. Essays in Index Number Theory, Volume 1, Contributions to Economic Analysis Series, D. W. Jorgenson, J. J. Laffont and T. Persson, ed. North-Holland, 1993 (hereinafter referred to as "Diewert (1993)").

methods give the same results when the **base year** for the computations is changed, and when the **normalization** of the data is changed from the price to the quantity series, or vice versa.

Theoretically, **marginal cost weights** should be used to aggregate outputs, as required by the economic theory of production.[2] The difficulty is that the econometric procedures required to estimate marginal cost weights may give results that change with small changes in the data or in the way that the model is specified. Statistically, results that are sensitive in this way are not **robust**. When marginal cost weights are estimated, their robustness should therefore be investigated and documented. Typically, in empirical regulatory economics, revenue weights are used when robust marginal cost weights are not obtained. In aggregating the components of interstate access services, the Performance-Based Model uses revenue requirements, which are related to estimates of long-term marginal costs. Absent better information, revenue weights are used to combine interstate access with other regulated services provided by the LECs.

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[2] Fisher and Shell (1972); Diewert (1993).

Issue 1b (p. 15)

What is the most appropriate measure of the cost of capital for a TFP study?

Response/Comments

The most appropriate measure of the cost of capital is **the cost assessed on the users of telephone services**. Any other approach drives a wedge between the total of the revenues paid by the customers and the costs captured in the TFP aggregation. This valuation of the capital stock is the amount that is **assigned by the regulatory process**. The **user cost of capital** is a long run concept that is based on the expectations of **future asset prices**, **corporate tax rates**, **investment tax credits**, the capital structure of the enterprise (i.e. **the debt-equity ratio**), the expected value of **future depreciation deductions**, and the **expected rate of return** to alternative investment opportunities.[3] The expected rate of return on debt is measured by **Moody's Yield on Public Utility Bonds**. The user cost is appropriate for aggregating the components of the stock into a single **capital aggregate index**. The **capital input**, or **flow of services** from the stock defined in this way, is proportional to the aggregated index of the capital stock.

For use in the measurement of TFP for the LECs, the price per unit of capital services, that is, per unit of the capital aggregate, is defined as the property income -- total revenue less variable cost (labor and materials expense), divided by the capital aggregate. This

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[3] See Norsworthy and Tsai (1996), chapter 3 (Attachment 2 to Appendix A); Jorgenson and Yun (1991).

procedure assigns the value to the capital stock that is charged to ratepayers, and is based on the **actual** performance of the LECs.

The value of the capital stock in production is computed differently: it is the **shadow cost** of the capital aggregate based on its contribution to production. The shadow cost is a kind of scarcity value of the capital input. This approach is consistent with the short run theory of production and productivity measurement based on the work of Berndt and Fuss (1986), who developed the methods for assigning a valuation to the capital input under conditions of disequilibrium, i.e. when the capital stock is not adjusted instantaneously to its long run equilibrium value. This approach is also consistent with the variable cost function approach developed several years ago by Brown and Christensen (1981). As in the case of marginal cost weights, the shadow cost of capital must be determined in an econometric model. It is therefore subject to the same problems of **robustness** that affect estimates of marginal costs of the various outputs.

The cost of capital sometimes changes substantially from year to year as conditions in financial markets change. The **cost of funds**, measured by Moody's Public Utility Bond Yield index, and adjusted for tax effects and the debt-equity ratio of the LEC, is the **expected rate of return** in the user cost equation. This rate will follow the financial markets closely, and hence should be updated annually. The corresponding changes in the TFP and X-Factor then can be readily computed and applied. Other elements in the determination of the X-Factor should be held constant until the next scheduled performance review.

Issue 1c (p. 16)

What are appropriate depreciation rates for a TFP study?

Response/Comments

In principle, **economic depreciation** rates are ideal for a TFP study. Economic depreciation properly includes two components: **loss of function** and **obsolescence**. Loss of function is generally appraised in terms of the **service life of an asset**. If an asset is expected to last for ten years in normal use, then straight-line depreciation (for example) would reduce the value of that asset by ten percent of its original cost each year for ten years. Obsolescence occurs when the economic usefulness of the asset is reduced by any of several factors, including **shifting demand** (the familiar plight of the buggy-whip manufacturers), **technological advance** (new, more cost-effective switching equipment) and **decline in the replacement cost of the asset** (which may be caused by technological advance or other reasons). Obsolescence can be detected empirically for assets that have active second-hand markets.[4] This was the methodology used in the Hulten and Wykoff (1981) study.[5] The data considered in their study ended in 1972 -- well before divestiture in 1984. Moreover, their study does not involve the telecommunications industry. Consequently, there is no telecommunications equipment that underlies the depreciation rates reflected in the USTA measures of TFP.

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[4] Norsworthy and Jang, Pacific Telecommunications Conference, 1991.

[5] The depreciation rates from Jorgenson, as cited in the USTA model, come from the Hulten-Wykoff study.

Thus, while it can be argued that economic and accounting depreciation are not congruent, that argument does not constitute a *positive* case for using depreciation rates from the 1970s and earlier for modern telecommunication equipment. Indeed, the Commission-authorized depreciation charges for the LECs have been increasing in recent years. Concerning the depreciation rates allowed by the FCC, its recent decision to allow amortization of the LECs' depreciation reserve deficiencies may be thought of as "catching up" on theretofore deferred obsolescence charges. The appropriate empirical approach to this important problem would be to collect data on recent transactions involving second-hand sales of telecommunication equipment by the LECs, and to carry out a study of depreciation using the Hulten-Wykoff methodology. Pending such a study, there appears to be no sound reason why the higher depreciation rates used in the USTA model should be accepted, nor is there any reason to accept the implied lower TFP and X-Factor measurements that appear to result from using these rates in the USTA model..

A strong case can be made for using **the depreciation rates prescribed by the Commission** in conjunction with the net book value of the capital stock, particularly when this value can be hedonically adjusted as in the Performance-Based Model. These rates average about 7.1 percent, about one percent lower than the rates used in the USTA model. The FCC depreciation rates have the great advantage of **conformance with the net capital stock reported in ARMIS**. The magnitudes of depreciation rates for different asset classes relative to each other may be reasonably accurate, because they reflect the interaction between regulation and industry practice over a long period of time.

I do not have the technical expertise to evaluate in detail whether the classifications of equipment recognized by the Commission for depreciation purposes are the most appropriate.[6] Clearly, central office switches should be (as they are) a separate category because of their rapid technological advance. The same reasoning applies to interoffice transmission equipment. Technological characteristics of switches (analog, digital, etc.) and of interoffice transmission equipment have proven useful in earlier work in hedonic adjustment of capital input for performance changes as measured by the marginal product of capital.

Depreciation rates for telecommunications plant and equipment are such a large portion of the total costs of the LECs that their accurate measurement is crucial for effective regulation. During the period before **effective competition** is established in local markets, greatly excessive or deficient returns, or declining service quality, may result from inadequate depreciation allowances. This is particularly true in a global telecommunications community, where **changes in standards** can make large investments obsolete almost overnight. Therefore, it is recommended that the Commission empanel a task force to (a) determine the availability of data, proprietary and public, for measuring depreciation rates, (b) specify and, in response to rapid critical review, modify an empirical methodology for measuring depreciation rates, and (c) make the best possible estimates of the rates in a reasonable period of time. The methodology review period should be

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6 These categories are (1) general support equipment, (2) central office equipment, (3) transmission equipment, (4) information originating and terminating equipment, (5) cable and wire, and (6) buildings.

relatively short. Only under such a plan can the Commission, the industry and the ratepayers be reasonably certain of fair and accurate charges for telecommunications services. The recommended task force should include a member of the Commission's economic staff and a disinterested economist with strong credentials in empirical measurement of depreciation.

Issue 1d (p. 18)

What is the most reasonable method to estimate capital stock?

Response/Comments

The capital stock should be measured by the perpetual inventory method, as conventionally applied in productivity analysis. As noted, economic depreciation is preferred for TFP measurement. Pending the development of appropriate estimates of economic depreciation, however, the rates authorized by the Commission are likely to be more accurate than the rates applied in the USTA model. As noted under Issue 1c above, the expected user cost of capital for each asset class should be applied to aggregate the capital into a single index. My comments in this response assumes that Issues 1c and 1d are dealt with as specified above.

Issue 1e (p. 19)

> **Is the imputation of capital services from capital stock rather than from capital consumption reasonable?**

Response/Comments

Yes. The only imputation of capital services that is consistent with the economic theory of production in both the long run and the short run is that the flow of capital services is proportional to the aggregate stock. Further, for measuring capital input for TFP, the stock itself should not be adjusted for utilization. As Berndt and Fuss clearly show, the utilization adjustment is properly part of the valuation of the stock, not the quantity of the capital stock or the corresponding capital input. Capital consumption is a cost of capital, not a measure of capital input, and therefore should not be used as a measure of capital input.

Issue 1f (p. 20)

> What is the most reasonable method for developing an implicit rental price?

Response/Comments

The best current definition of the rental price or user cost of capital[7] is in the work of Professor Dale W. Jorgenson (1991, 1993).[8] For application to regulatory economics, his approach should be modified to allow for a reasonable return to financial capital, as

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[7] The terms are used interchangeably in the production literature.

[8] Jorgenson and Yun (1991) and Jorgenson and Landau (1993) chapter 1.

specified in Norsworthy and Tsai (1996).[9] As noted under Issue 1b above, the short run value of the capital stock for use in TFP measurement should *not* be the rental price, but the unit value of the capital stock as defined there.

By these standards, the USTA user cost formulation is deficient in several respects. It ignores the effect of debt financing on the cost of funds, and thus overstates the user cost of capital by about 30%. It is not consistent with the *ad hoc* adjustments to market values applied in the USTA model.

Issue 1g (p. 21)

> What is the most reasonable method for developing a labor index for inclusion in a TFP calculation?

Response/Comments

The conventional and appropriate method for developing an index of labor input is to aggregate the various components of labor -- measured as employment or hours in different occupational categories -- weighted by their shares in total labor expenditures of the enterprise: the LEC or aggregate of the LECs. This procedure adjusts for the "quality" of the labor input as defined in terms of the occupational composition of the work force.[10]

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[9] Forthcoming from Kluwer Academic Publishers. Chapter 3, which deals with modifying the user cost of capital to conform with basic financial theory and practice, is included as Attachment 2 to Appendix A.

[10] Other dimensions of the workforce also can be taken into account by this

(continued...)

The USTA model devises such an index of labor input based on employment and compensation in two categories of workers: management and non-management. These data are routinely reported to the FCC; generally speaking, their use in such a procedure would be unexceptionable.

When we examined the supporting data, however, we observed the large increase in labor compensation at the aggregate of the Ameritech LECs in the early 1990's associated with the expenses for early separation of management employees. The principle in productivity analysis underlying the aggregation of labor is that the various occupations are rewarded according to their respective contributions to production -- their marginal products. Whatever the justification that may have been advanced for the extraordinary separation payments by Ameritech, there is no doubt that the productivity of its labor force did not jump in a single year in the manner that the compensation of management would suggest, and then decline in the following year. From the perspective of productivity analysis, as well as sound accounting practice, the separation payments should be charged against profits (property income, as observed in the discussions of the USTA model and the Performance-Based Model in Appendix A) rather than labor compensation. Consequently, until and unless there is sufficient information to adjust for this anomaly, it

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(...continued)

method according to the data available, such as education, experience, and demographic details. See Jorgenson, Gollop, and Fraumeni (1987). This measure of labor quality rests upon the assumption that each category of labor is paid according to its marginal product. consequently, short-term changes in labor quality measured in this way are less likely to be accurate than long-term trends. The measure is used for the latter purpose by Jorgenson, et al.

was determined to use an unweighted aggregate of employment as the measure of labor input in the Performance-Based Model.

Issue 1h (p. 21)

> What is the most reasonable method for developing a materials index for inclusion in a TFP calculation?

Response/Comments

To overcome the deficiency in the input price differential that derives from USTA's use of the GDP-PI as the deflator for materials prices, a materials input price deflator was developed for use in the Performance-Based Model. The method for developing the index is described below; it represents the best approximation to a materials price index for the LECs, based on publicly available data.

The materials price index used in the Performance-Based Model is based on expenditure weights from the Communications industry in the 1977, 1982, and 1993 input-output (I/O) tables for the United States, prepared by the U.S. Bureau of Labor Statistics (BLS). We obtained the Bureau of Labor Statistics 183-order Interindustry Accounts. These accounts are available for the years 1977, 1987, and 1993. The corresponding 183-order industry deflators were available for the same periods from BLS.

The general procedure applied in computing a materials price index for inputs purchased by the LECs is quite similar to those used by the BLS in its construction of the **Consumer Price Index** and the **Producer Price Index**. **Input weights** are computed for each input

for each year. Inputs, whether goods or services, are designated **commodities** for convenience. **Commodity prices** for each year are likewise taken from the BLS Interindustry Accounts, and so are consistent with the commodity and industry definitions. For each year, the input weights are computed so as to add to one. These weights are multiplied by the corresponding commodity prices and summed to a **materials input price index**.

This approach has limitations although it is markedly superior to USTA's use of the GDP-PI to deflate materials. The weights are based on the whole telecommunications industry, and may differ from the weights that would be derived from the expenditures of the LECs. The corresponding commodity prices represent the economy as a whole, which may differ from the prices paid by the LECs. However, the input weights are a far superior representation of the purchases of the LECs than those in the price index for GDP (the GDP-PI), which the USTA model uses to represent the prices of materials. Similarly, the prices are those of commodities used in telecommunications, rather than the value-added based prices for all of the goods and services produced in the private economy as a whole, as assumed by the USTA model.

A preferred alternative would be to base a materials price index on survey data obtained directly from the LECs. The survey would collect sample data on goods and services purchased by the LECs in actual transactions, with the value of the transaction, and the associated price and quantity of the good or service specified. The data supplied in the survey would necessarily be subject to a confidential audit.

The methods proposed here could readily be adapted to use data on prices and expenditures on goods and services purchased by the LECs. It is recommended that such data be routinely reported annually in ARMIS, as long as LEC price cap regulation remains in force.

Substantial economies, as well as benefits to the quality of the TFP and X-Factor measures, would be achieved by extending the LECs' survey and/or their reporting requirements to include purchases of capital goods as well, particularly switches and transmission equipment, and integrating the measurement activity with the depreciation studies recommended above. Until such steps are completed and reviewed, the materials price index we have developed is as good as can be obtained from publicly available data.

Issue 1i (p. 22)

> What is the most reasonable way to account for changes in LECs' input prices for use in a TFP approach to calculating the X-Factor?

Response/Comments

The best estimate of the input prices of the LECs achievable in a short period of time is illustrated by the index computed for the Performance-Based-Model, as discussed in Appendix A (e.g., pp. 17-22, 71-72). For convenience, much of that discussion is excerpted and repeated below. This methodology would be improved by the survey of materials and capital prices outlined above in the response to Issue 1h above.

In the Performance-Based Model, labor, materials and capital input prices are computed for the aggregate of all RBOCs and combined into an aggregate input price index for the RBOCs. The price index method applied is the **Fisher Ideal Price Index** recommended in Diewert (1993)[11] for application to productivity analysis. When this index is computed, the results are those shown in Table 2. The **Tornquist Index** (a discrete form of the continuous **Divisia Index**) used in the USTA model is a poor choice for exacting productivity measurement because its results vary according to whether TFP is computed from the price or quantity side.[12]

Table 2 below shows the movements in the labor, materials and capital price indices for all RBOCs in the post-divestiture period, omitting 1984. Also shown are the input price indices for the non-farm private business sector and the RBOCs.

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11 Diewert (1993).

12 Duality between the cost and quantity models of production asserts that TFP growth should have the same value whether computed from quantity changes or price changes. There is no theoretical reason to prefer one method over the other. However, when the Tornquist Index is applied to the price and quantity data for the RBOCs, there are differences between the two results. The Fisher Ideal Index gives the same results; we thus have used that method.

Table 2. Input Price Indices for RBOCs

	ALL INPUTS NON-FARM BUSINESS 1985 = 1.000	LABOR ALL RBOCs 1985 = 1.000	MATERIALS ALL RBOCs 1985 = 1.000	CAPITAL ALL RBOCs 1985 = 1.000	ALL INPUTS ALL RBOCs 1985 = 1.000
1985	1.000	1.000	1.000	1.000	1.000
1986	1.030	1.025	1.021	1.112	1.056
1987	1.056	1.036	1.035	1.082	1.052
1988	1.096	1.064	1.059	0.862	0.986
1989	1.130	1.071	1.099	0.839	0.882
1990	1.168	1.158	1.143	0.832	0.952
1991	1.192	1.216	1.169	0.597	0.962
1992	1.228	1.223	1.194	0.612	0.979
1993	1.271	1.333	1.206	0.664	1.037
1994	1.310	1.373	1.234	0.651	1.043
Growth for Period	**3.00%**	**3.52%**	**2.34%**	**-4.77%**	**0.46%**

Note: Rate of growth for Nonfarm Business 1985-93 is extrapolated to 1994

Source: Computed in Performance-Based TFP Model from data in BOC reports to FCC.

As these results from Table 2 illustrate, the input price differential is quite substantial. Contrary to USTA's position, it should be included in the X-Factor. The alternative advocated by USTA is to ignore entirely the input price differential. To do so would be to grant the LECs a windfall of several billion dollars per year in a three year price cap period -- all at the expense of the ratepayers.

The Frentrup-Uretsky and the Bush-Uretsky studies to determine the input price differential represent a *tour de force* of quantitative inference. Their shortcoming, however, is that they must rely on other aspects of the USTA model for their accuracy, specifically, the idiosyncratic pricing of the capital input, as discussed in Appendix A, and the biased measure of output. For this reason, the direct measurements of the LECs' input prices and of the corresponding input price differential, reported in Appendix A (pp. 17-22), are more accurate. As noted above, these measurements could be improved with data collected directly from the LECs.

Issue 1j (p. 25)

> Is there a valid distinction between intrastate and interstate productivity for the purposes of calculating a TFP index and an input price index and, if so, does a satisfactory method exist to account for such differences?

Response/Comments

Yes. The issue of separating the LECs' interstate and other TFP has been addressed in Appendix A.

As noted above, interstate access services provided by the LECs have grown more rapidly than local service or intrastate toll service. Table 1 above showed rates of growth for three categories of telephone service in the 1985-1994 period. I explained in Appendix A why these measures of activity represent the services provided by the LECs better than the categories of deflated revenues in the USTA model. In summary, the three broad categories of LEC service are priced differently, sold to different customers, and/or regulated by different authorities. The interstate output index and minutes of use for

intrastate toll service are traffic-sensitive, as are the bulk of charges assessed for these services, and more directly so than deflated toll revenues. Interstate access services have grown at an annual rate of 6.83 percent, while other regulated services, intrastate and local, have grown at an annual rate of 4.22 percent (when these services are combined into a single Fisher Ideal Quantity Index[13]).

Furthermore, as I have stated, interstate access services rely more on fixed inputs, e.g. switches and transmission equipment, and less on labor and materials inputs than local service. Consequently, there should be greater economies of scale in the LECs' provision of interstate access than in their provision of other telephone services. **Therefore, if we assume that inputs grow at the same rates for interstate access and other regulated telephone services provided by the LECs, the resulting implied allocation of costs, reflected in the Performance-Based Model is conservative.** This conservative bias is retained even after adjustment for jurisdictional separations data concerning relative revenue and expenses growth, as reported in Table 7A of Appendix A. It is important to note, however, that no specific allocation of costs is required by the assumption that inputs grow at the same rates for all classes of service, although that assumption is consistent with the allocation of all costs in proportion to revenues. Making this conservative assumption permits the computation of TFP separately for interstate access and the LECs' other regulated services (local and intrastate) in a way that combines to measure directly the TFP on a total company basis.

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[13] Diewert (1993).

Clearly, it is entirely feasible to calculate separate measures of TFP and the X-Factor for interstate access services and other regulated telephone services for the LECs, based on conservative assumptions about costs and direct measurement of outputs in those respective sectors, using only publicly available data. This said, if more specific data concerning the LECs' expenditures and prices of materials were reported, further improved estimates of the input prices and the input price differential, as well as the associated TFP and X-Factors, could be achieved.

Moreover, the use of recent jurisdictional separations data about the relative growth in interstate revenues and expenses is helpful in further refining the measurement of TFP separately for the LECs' interstate access services. A central question that arises in addressing this issue concerns the role that jurisdictional separations of costs could and should play in calculating separate TFP and X-Factors for interstate and "other" components of the LECs' regulated business. Examination of these separations data during the LEC price cap period from 1991 to 1994 shows that the LECs' interstate growth in revenues per dollar of input expense exceeded their interstate growth in expenses by 1.29 percent per year. An adjustment can be made to the calculations of TFP and X-Factor shown in Appendix A (Table 7, p. 28) to reflect this information, because Table 7 is based on the assumption that interstate inputs grew at the same rate as did the LECs overall. If it is assumed that the LECs' interstate growth in inputs in proportion to revenues matched the LECs' overall input growth in the 1985-1990 period, but that the LECs' interstate inputs-to-revenues ratio grew less than the growth in their interstate expenses by 1.29 percent per year in the 1991-1994 period (as indicated by the separations