noteworthy that basing the output index on marginal cost weights instead of revenue weights would reduce the measured rate of total factor productivity growth, since the cost elasticity weights give greater weight to output categories that have experienced lower growth. Crandall and Galst[11] estimate that using a cost-elasticity based output index instead of a revenue based output index reduces the annual rate of telephone industry TFP growth by 1.7 percentage points over the 1981-1988 period. Fuss[12] estimates that using a cost-elasticity based output index instead of a revenue based output index reduces the annual rate of Bell Canada TFP growth by 2.0 percentage points over the 1980-1989 period.

In our original study, the computation of quantity indexes for long distance and intrastate access were obtained by dividing billed revenue by a price index reflecting prices paid by consumers. Billed revenue is not available from publicly-available data sources, however, and therefore the FCC may not feel that the series are adequately accessible and verifiable. In the simplified model, we construct the quantities of long distance and intrastate access services from booked revenue. Booked revenue is published in the ARMIS 43-02 and therefore meets the FCC criteria of accessibility and verifiability. In Table 2 we compare the measured growth

[11] Robert W. Crandall and Jonathan Galst, "Productivity Growth in the U.S. Telecommunications Sector: The Impact of the AT&T Divestiture," The Brookings Institution, February 1991.
[12] Melvyn A. Fuss, "Telecommunications Growth in Canadian Telecommunications," Canadian Journal of Economics, May 1993.

in output when booked revenue is used instead of billed revenue. As one can see from the table, this modification produces similar results.

Table 2
Sensitivity Analysis:
Original Christensen LEC TFP Study Results Versus
Use of Booked Revenue for Long Distance and Intrastate Access
1984-1993

Year	TFP Growth Original Study	TFP Growth Using Booked Revenue
1984		
1985	1.1%	1.5%
1986	2.8%	2.9%
1987	1.8%	1.9%
1988	2.1%	2.4%
1989	2.0%	1.9%
1990	4.6%	5.0%
1991	1.2%	1.3%
1992	3.5%	3.9%
1993	2.6%	3.2%
Average, 1984-93	2.4%	2.6%

Issue 1b. What is the most appropriate measure of the cost of capital for a TFP study?

In our original study, we used the Moody's public utility bond yield as a proxy for the cost of capital. We used the Moody's bond yield because (1) it is publicly available, (2) it is updated annually, and (3) our TFP results were not very sensitive to this choice. The reason that our TFP results were not greatly affected by our choice of the Moody's bond yield is that the cost of capital does not affect the measured quantities of input for different capital asset classes, and only has a slight impact on the weights given the different capital asset classes in measured total input. Therefore, total input changes by only a slight amount.

The actual cost of capital for Local Exchange Carriers is an average of the cost of debt and the cost of equity. In response to the FCC's questions regarding the appropriate cost of capital, our simplified TFP method employs a proxy for the cost of capital that includes both the cost of debt and the cost of equity. The simplified TFP method uses the cost of capital for the U.S. economy implicit in the U.S. National Income and Product Accounts, as discussed in the Christensen affidavit of February 1, 1995.[13] Because capital markets are national and because the riskiness of telephone assets and other assets in the U.S. economy are similar, year-to-year changes in the telephone industry cost of capital should follow year-to-year changes in the U.S. economy cost of capital. Furthermore, using the cost of capital implicit in the U.S. National Income and Product Accounts would treat LEC and economy-wide capital costs symmetrically. All the data used to compute the U.S. economy cost of capital are produced by the U.S. Bureau of Economic Analysis and are publicly available. Therefore they meet the FCC criteria of accessibility and verifiability.

The data that are used to calculate the U.S. cost of capital are also released annually; therefore the cost of capital can be calculated each year

[13] "An Input Price Adjustment Would be an Inappropriate Addition to the LEC Price Cap Formula: Affidavit of Dr. Laurits R. Christensen on Behalf of the United States Telephone Association," CC Docket No. 94-1, February 1, 1995.

in a straightforward manner. This will allow the cost of capital to be kept current in the rental price equation. Table 3 compares the measured growth in TFP when the U.S. cost of capital is used instead of Moody's bond yield.

Table 3
Sensitivity Analysis:
Original Christensen LEC TFP Study Results Versus
Use of U.S. Cost of Capital for Measuring LEC Cost of Capital
1984-1993

Year	TFP Growth Original Study	TFP Growth Using U.S. Cost of Capital
1984		
1985	1.1%	1.1%
1986	2.8%	2.6%
1987	1.8%	1.6%
1988	2.1%	2.1%
1989	2.0%	1.9%
1990	4.6%	4.3%
1991	1.2%	1.0%
1992	3.5%	3.1%
1993	2.6%	2.4%
Average, 1984-93	2.4%	2.2%

The FCC asks whether the authorized rate of return should be used as the LEC cost of capital. While the FCC's authorized rate of return also includes debt and equity components, it continues the regulatory burden of represcription proceedings. Furthermore, the effort involved in these proceedings is significant enough that they are conducted infrequently, and therefore can lead to relatively large stepwise changes in the authorized rate of return. This in turn would increase the volatility of the implicit rental prices. These difficulties with the authorized rate of return make it an inferior alternative to the U.S. cost of capital.

To summarize, while Moody's bond yield provides a good proxy to the LEC cost of capital for purposes of measuring LEC TFP growth, it does not incorporate an equity component. To address this concern, our simplified method uses the cost of capital in the U.S. economy as a proxy for the LEC cost of capital. We believe that this represents the best available measure of the cost of capital for the LEC TFP study.

Issue 1c. What are appropriate depreciation rates for a TFP study?

The economic rates of depreciation that we used in our original TFP study are based on extensive academic research. This research has previously been summarized by Hulten and Wykoff [14] and Hulten.[15] This research points to the conclusion that depreciation for classes of assets is geometric, and that this geometric rate of depreciation is tied to the lifetimes of the assets in the class.[16] Hulten and Wykoff developed economic depreciation rates for broad categories of assets, based on expected lifetimes used by the U.S. Bureau of Economic Analysis and the

[14] Charles R. Hulten and Frank C. Wykoff, "The Measurement of Economic Depreciation," in C.R. Hulten, ed., Depreciation, Inflation, and the Taxation of Income from Capital, (Washington DC: Urban Institute, 1981), pp. 81-125.
[15] Charles R. Hulten, "The Measurement of Capital," in E.R. Berndt and J.E. Triplett, eds. Fifty Years of Economic Measurement, (Chicago: University of Chicago Press, 1990), pp. 119-152.
[16] Hulten and Wykoff found that the depreciation rate for equipment equals 1.65/T and the depreciation rate for structures equals .91/T, where T is the expected useful life of a newly-installed asset.

U.S. Bureau of Labor Statistics for purposes of measuring capital in the U.S. economy. Jorgenson updated the Hulten-Wykoff rates for recent changes in the Bureau of Economic Analysis expected lifetimes.[17]

Based on the fact that the rates we used in our original study are consistent with the economic literature on depreciation and because they are based on the lifetimes currently used by the U.S. Bureau of Economic Analysis and U.S. Bureau of Labor Statistics, we believe that they are the most appropriate rates for use in a TFP study. Given that the Bureau of Labor Statistics uses the same lifetimes as those used in our original study, there exists a symmetry between our TFP study and the Bureau of Labor Statistics measure of productivity for the U.S. economy. We therefore employ the same depreciation rates in the simplified TFP method.

The U.S. Bureau of Economic Analysis reviews and adjusts its expected lifetimes approximately every five years, in conjunction with its capital stock benchmark revisions. It would be appropriate to adjust the simplified TFP method depreciation rates whenever the Bureau of Economic Analysis makes substantial revisions to its lifetimes. The new depreciation rates would be derived from the Hulten-Wykoff formulas linking depreciation rates to expected lifetimes.

[17] Dale W. Jorgenson, "Productivity and Economic Growth," in E.R. Berndt and J.E. Triplett, eds. Fifty Years of Economic Measurement, (Chicago: University of Chicago Press, 1990), pp. 19-118.

The FCC asks whether prescribed depreciation rates should be used in the productivity study. Since prescribed depreciation rates are not based on economic theory or on recent empirical research on economic depreciation, they may differ substantially from economic depreciation. Similarly, the bands established by the FCC for streamlined treatment of depreciation are not based on economic theory or recent empirical research, and therefore the bands may not establish reliable bounds for economic depreciation rates. In conclusion, prescribed depreciation rates should not be used in the productivity study.

The Commission also asks whether the computation of capital input should be based on the thirty capital accounts under Part 32 rules instead of the six accounts in our study. We do not believe that it is possible to obtain all the detailed data needed to construct a capital input measure based on thirty capital accounts. Furthermore, any movement in this direction would be in conflict with the FCC stated goal of simplifying the calculation.

Issue 1d: What is the most reasonable method to estimate capital stock?

In our original TFP study we employed the perpetual inventory method to measure capital stock. The perpetual inventory method is widely used in productivity research, is currently used by the U.S. Bureau of Labor Statistics in all of its total factor productivity studies, and is the most reasonable method for measuring capital stock in a LEC TFP study. In order to improve upon the perpetual inventory method, one would need to collect information on all LEC plant and equipment, by vintage, for each year of the LEC study.[18] The data requirements for such an approach are prohibitive. Because the perpetual inventory method is the most reasonable approach for measuring capital stock, we use it for purposes of measuring capital stock in the simplified TFP method.

The proper basis for establishing the benchmark or starting value of capital in the perpetual inventory equation is consistency with the depreciation assumptions employed in the study. Both our original study and the simplified TFP method are based on the economic rates of depreciation, which are geometric rates. Therefore the starting value of capital must be consistent with these economic depreciation rates. Furthermore, the benchmark cannot be contaminated by changes in the purchase prices of new assets over time.

In our original study, the LECs were able to provide us with current-cost of gross stock estimates of end-of-year 1984 plant and equipment.[19] This provided us the basis for the benchmark. The current-cost of gross

[18] For a survey of the methods used to construct capital stock indexes, see Dale W. Jorgenson, "Capital as a Factor of Production," in D.W. Jorgenson and R. Landau, eds., Technology and Capital Formation, (Cambridge MA: MIT Press, 1989), pp. 1-35, and Charles R. Hulten, "The Measurement of Capital," in E.R. Berndt and J.E. Triplett, eds. Fifty Years of Economic Measurement, (Chicago:University of Chicago Press, 1990), pp. 119-152.

[19] The current-cost of gross stock was also referred to as the replacement value of the stock.

stock correctly adjusts for changes in the purchase price of new assets over time, but it does not adjust for economic depreciation.

In order to incorporate the effects of depreciation on the benchmark value, the current-cost of gross plant was multiplied by the Economic Stock Adjustment Factor. The Economic Stock Adjustment Factor represents the ratio of the stock's economic value to the current cost of gross stock. Conceptually, there is no "choice" regarding the basis for Economic Stock Adjustment Factor; the only appropriate factor is the ratio of the economic value of capital stock to gross stock in current dollars. In order to measure this ratio, one needs information on the age distribution of assets in the telephone industry. We used best publicly-available information on the age distribution of telephone industry assets -- that collected by the Bureau of Economic Analysis for purposes of constructing capital stock estimates for the telephone and telegraph industry.

Because the company's 1984 current cost of gross stock is not obtained from a publicly-available data source, it may not meet the FCC's accessibility and verifiability criteria. For that reason, the benchmarks in the simplified TFP method are based on the original cost (book value) of gross stock, reported in the Form M.[20] The book value of gross stock does not

[20] The benchmark is also established for beginning-of-year 1988, using the Part 32 accounting categories. Moving the benchmark to 1988 and basing it on Part 32 accounts simplifies the computational procedures. One must recognize, however, that the beginning-of-year 1988 plant and equipment reported using Part 32 still contains assets that are expensed rather than capitalized in later years. Therefore one must take this into account when establishing the benchmark.

adjust for either economic depreciation or changes in the purchase prices of new assets over time. Therefore the book value of gross stock needs to be multiplied by its own Economic Stock Adjustment factor, one that incorporates both depreciation and changes in the purchase prices of new assets. This adjustment factor is the ratio of the economic value of the stock to the book value of gross stock. To avoid confusion with the Economic Stock Adjustment factor used in the original study, we refer to the adjustment factor in the simplified TFP method as the Economic Value/Book Value Adjustment Factor.

Neither the book value of gross plant nor the book value of net plant can be used as benchmark values in the perpetual inventory equation unless they are adjusted for economic depreciation and inflation in the purchase prices of new assets. Either can be used if it is correctly adjusted; furthermore the correctly adjusted book values of gross and net plant will produce the same benchmark. Table 4 shows the impact on measured TFP growth of using the beginning-of-year 1988 book value of stock to estimate capital benchmarks.

Table 4
Sensitivity Analysis:
Original Christensen LEC TFP Study Results Versus
Use of 1988 B-O-Y Book Value of Gross Stock to Estimate Capital Benchmarks, 1984-1993

Year	TFP Growth Original Study	TFP Growth Using 1988 Book Value of Stock
1984		
1985	1.1%	1.4%
1986	2.8%	3.0%
1987	1.8%	2.0%
1988	2.1%	2.3%
1989	2.0%	2.1%
1990	4.6%	4.7%
1991	1.2%	1.3%
1992	3.5%	3.6%
1993	2.6%	2.7%
Average, 1984-93	2.4%	2.6%

In order to apply the perpetual inventory equation, book value of investment must be converted to the quantity of investment. This is achieved by dividing the book value of investment by a price index representing the prices paid for plant and equipment. In our original study this was done by dividing book value by Telephone Plant Indexes (TPIs) provided by the LECs. We used the TPIs in our original study because we believed that they provided the best information on prices actually paid by LECs for plant and equipment.

The TPIs are based on proprietary data and therefore are not readily accessible and verifiable. Because of the FCC's stated concerns regarding accessibility and verifiability, the simplified TFP method does not rely on the

TPIs. Instead the quantities of investment are calculated by using U.S. Bureau of Economic Analysis (BEA) price indexes for nonresidential structures and producer durable equipment. While BEA price indexes are not based on the prices actually paid by LECs for plant and equipment, they provide a reasonable approximation to them.

The simplified TFP method uses the BEA telephone structures price index for buildings and cable and wire. For central office switching equipment, transmission equipment, and information origination/termination equipment, the simplified TFP method uses the BEA producer durable equipment price index for communications equipment. For general support equipment, the simplified TFP method uses a Tornqvist index of four BEA producer durable equipment price indexes: office, computing, and accounting machinery; furniture and fixtures; trucks, buses, and truck trailers; and non-residential producer durable equipment. The weights used in the Tornqvist index are based on the book value of gross additions in general purpose computers, furniture and office equipment, motor vehicles, and other general support equipment. Table 5 shows the impact on measured TFP growth of using BEA price indexes to obtain investment quantities.

Table 5
Sensitivity Analysis:
Original Christensen LEC TFP Study Results Versus
Use of BEA Price Indexes to Obtain Quantity of Investment
1984-1993

Year	TFP Growth Original Study	TFP Growth Using BEA Price Indexes
1984		
1985	1.1%	0.9%
1986	2.8%	2.8%
1987	1.8%	1.8%
1988	2.1%	2.1%
1989	2.0%	2.0%
1990	4.6%	4.8%
1991	1.2%	1.3%
1992	3.5%	3.6%
1993	2.6%	2.8%
Average, 1984-93	2.4%	2.5%

To summarize, the method and data sources employed in our original study provided an accurate measure of LEC capital stock. Because of the FCC's stated concerns regarding the accessibility and verifiability of all data used to construct capital stocks, we have proposed a simplified method for computing capital stock that is based entirely on publicly-available data using the same method for measuring capital stock as our original study.

Issue 1e: Is the imputation of capital services from capital stock rather than from capital consumption reasonable?

Capital stock is the most reasonable basis for measuring the quantity of capital input, and in fact it is the standard approach in productivity research. For example, the Bureau of Labor Statistics uses capital stock to impute capital services in all total factor productivity studies.[21] The reason that capital stock accurately represents the quantity of capital input is that it weights each vintage of plant and equipment by its relative production efficiency. This means that the stock represents the total amount of capital services that are available for production.

The FCC has defined capital consumption as "the loss of capital efficiency over time." There is no reasonable basis to believe that capital services provided in any year equals the amount by which an asset has lost efficiency. For example, a light bulb maintains a high level of efficiency over a number of years, while providing a high level of service during that time. Yet using capital consumption to measure capital services would incorrectly imply that the light bulb has provided little service.

Both our original TFP study and the simplified TFP method use the quantity of capital stock to measure the quantity of capital input for each asset class. This is the accepted standard in productivity research.

Issue 1f. What is the most reasonable method for developing an implicit rental price?

The implicit rental price formula employed in both the simplified study and our original TFP study is rigorously developed from the economic theory

[21] See U.S. Department of Labor, Bureau of Labor Statistics, Trends in Multifactor Productivity, 1948-81, Bulletin 2178, September 1983, pp. 39-58.

of capital, and provides an accurate estimate of the implicit rental price for purposes of estimating TFP. This theory is based on a market equilibrium relationship between the price a firm is willing to pay to acquire an asset and the services that it provides over its lifetime. While theoretically correct, it is recognized that the implicit rental price formula can generate more volatility in rental prices than is found in observed rental prices. Therefore, we have sought to reduce the volatility in our rental price formula. Harper, Berndt, and Wood[22] recently evaluated a variety of rental price equation formulations. One method they consider is to base the rental price equation on three-year moving averages of the cost of capital and capital gains, instead of their current values. The three-year moving average approach yields considerably more stable implicit rental prices than in our original study. We use the three-year moving average approach in the simplified method. Table 6 shows the impact on measured TFP growth of basing the rental price equation on three-year moving averages of the cost of capital and capital gains.

[22] Michael J. Harper, Ernst R. Berndt, and David O. Wood, "Rates of Return and Capital Aggregation Using Alternative Rental Prices," in D.W. Jorgenson and R. Landau, eds., Technology and Capital Formation, (Cambridge MA: The MIT Press, 1989), pp. 331-372.

Table 6
Sensitivity Analysis:
Original Christensen LEC TFP Study Results Versus
Use of Three-Year Moving Average in Rental Price Equation
1984-1993

Year	TFP Growth Original Study	TFP Growth Using Three-Year Moving Average
1984		
1985	1.1%	1.2%
1986	2.8%	2.7%
1987	1.8%	1.8%
1988	2.1%	2.1%
1989	2.0%	2.0%
1990	4.6%	4.6%
1991	1.2%	1.3%
1992	3.5%	3.6%
1993	2.6%	2.6%
Average, 1984-93	2.4%	2.4%

Differences between the rental price equation in our original study and the rental price equation in the simplified TFP method do not have a significant impact on measured TFP growth. This is because changes in rental prices do not affect the quantities of capital input and only have a minor effect on the capital input weights in total input.

Issue 1g. What is the most reasonable method for developing a labor index for inclusion in a TFP calculation?

Economic theory holds that the quantity of labor input is related to the hours worked by LEC employees, weighted by their relative compensation levels. In our original TFP study we distinguished management and non-management employees, because of their different levels of compensation. The quantity of labor input was constructed as a Tornqvist index of management and non-management employees, using their relative compensation levels as weights. This was the most detailed breakdown of employee hours and compensation that was available. Consequently it provided the most accurate measure possible of labor input.

Even this limited breakdown of hours and compensation required non-publicly-available data from various internal company records. In order to achieve the FCC's objective of basing the computations on accessible and verifiable data, the simplified TFP method bases its measure of labor input on the total number of employees, which is reported in the Form M. While changes in the total number of employees from year to year will not exactly match changes in hours worked or changes in the mix between management and non-management employees, it provides an attractive balance between accuracy and verifiability. Table 7 shows the impact on measured TFP growth of using the total number of employees as the measure of labor input.

Table 7
Sensitivity Analysis:
Original Christensen LEC TFP Study Results Versus
Use of Total Employees to Measure Labor Input
1984-1993

Year	TFP Growth Original Study	TFP Growth Using Total Employees
1984		
1985	1.1%	1.6%
1986	2.8%	2.1%
1987	1.8%	2.6%
1988	2.1%	3.0%
1989	2.0%	1.9%
1990	4.6%	4.1%
1991	1.2%	1.7%
1992	3.5%	2.9%
1993	2.6%	3.6%
Average, 1984-93	2.4%	2.6%

The FCC has also asked how post-retirement benefits will affect the measure of labor input. Post-retirement benefits affect labor compensation reported in the Form M/ARMIS 43-02, but it does not affect the number of employees, which is the basis for determining the quantity of labor input in the simplified TFP method. This means that the post-retirement benefits will slightly increase the labor's share of total input. Since the quantity of labor has been falling relative to the quantity of other inputs, this would mean that the inclusion of post-retirement benefits in labor's share of cost will slightly increase the rate of measured TFP growth.

Issue 1h. What is the most reasonable method for developing a materials index for inclusion in a TFP calculation?

In our original TFP study we used the Gross Domestic Product Price Index to reflect price trends for materials. This was done for two reasons. First, the ARMIS 43-02 Report, which was our public data source for materials expenditures, does not provide a breakdown of materials expenditures by type of good or service. Second, information was not available on prices paid by LECs for their materials. Because materials expenditures are diverse in nature, and because the GDPPI reflects overall inflation in the economy, it provides the most reasonable basis for developing a materials price index.

Because the GDPPI is the most reasonable basis for the materials price index, the simplified TFP method also uses the GDPPI to deflate materials expense.

Issue 1j. 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?

There is no valid distinction between intrastate and interstate productivity or between intrastate and interstate input prices. This is because there is no economically valid distinction between intrastate and interstate inputs. Intrastate and interstate services have joint and common inputs and there is no economically meaningful allocation of these inputs between jurisdictions: any allocation of these inputs between intrastate and interstate services is arbitrary. We make no attempt to arbitrarily measure interstate and intrastate TFP growth in either our original TFP study or the simplified TFP method.

Issue 1k. Is there a valid distinction between regulated and nonregulated productivity, or the productivity associated with specific services, such as video dialtone, or groups of services, for purposes of calculating a TFP index and an input price index? If so, does a satisfactory method exist to account for such differences?

TFP can be calculated for specific services or groups of services only if they do not share joint and common inputs with other services. Both our original TFP study and the simplified TFP method measures TFP for all services that have joint and common inputs with regulated services. Under Part 32 accounting rules, nonregulated services that have joint and common inputs with regulated services are included in operating revenue and operating expense. Hence those services were included in our TFP study. Nonregulated services that have no joint and common inputs with regulated services are not included in operating revenue or operating expense and were not included in our TFP study. Therefore the original TFP study and the simplified method correctly group services for purposes of measuring TFP growth.

The Simplified TFP Method

Because of the concerns raised by the FCC regarding the accessibility and verifiability of some of the data used in our original TFP study, we have developed a simplified TFP method that is based entirely on publicly-available data. A few additional modifications to our original study have also been made in the simplified TFP method, to address other concerns raised by the FCC. At the same time, the simplified TFP method is consistent with accepted productivity measurement practices and provides an accurate measure of productivity trends for LECs. Therefore, we believe the simplified TFP method maintains accuracy in measurement as well as a proper balance between precision in measurement and verifiability

We now summarize the differences between the methods and data sources in our original study and the methods and data sources in the simplified TFP study:

Output. The only way in which the measurement of output in the simplified model differs from the measurement of output in the original study is that the quantity of long distance service and the quantity of intrastate access service are derived by dividing booked revenue (as opposed to billed revenue), reported in the Form M, by the price indexes for long distance and intrastate access service.

Capital. There are five differences between the simplified model and the original TFP study regarding the measurement of capital. First, the simplified study uses the U.S. economy cost of capital implicit in the U.S. National Income and Product Accounts as the cost of capital in the rental price equation, instead of Moody's average yield on public utility bonds. Second, the simplified TFP method uses investment price indexes published by the U.S. Bureau of Economic Analysis instead of Telephone Plant Indexes. The BEA non-residential structures price index for telephone and telegraph structures is used for buildings and cable and wire. The BEA producer durable equipment price index for communications equipment is used for switching equipment, transmission equipment, and information origination/termination equipment. The price index for general support equipment is a Tornqvist index of four BEA producer durable price indexes: office, computing, and accounting machinery; furniture and fixtures; trucks, buses, and truck trailers; and non-residential producer durable equipment. The weights used in the Tornqvist price index are based on book value of investment in general purpose computers, furniture and office equipment, motor vehicles, and other general support equipment, reported in the Form M. Third, the simplified TFP method employs beginning-of-year 1988 book values of gross plant, reported in the Form M, in the derivation of the capital benchmarks, instead of end-of-year 1984 current-cost of gross plant. The book value of gross plant is multiplied by the Economic Value/ Book Value

Adjustment Factor in order to derive the benchmark. Fourth, the simplified TFP method uses three-year moving averages of the cost of capital and capital gains in the rental price equation. Fifth, since some of the asset classes have the same BEA price indexes and depreciation rates, it is possible to simplify the computational procedures by consolidating those accounts. This consolidation does not affect the computed values or quantities of capital input and, therefore, does not affect measured TFP. Buildings and cable and wire are consolidated into structures. Switching, transmission, and information origination/termination equipment are consolidated into communications equipment. General support equipment is not affected by this consolidation.

Labor. The simplified TFP method bases the quantity of labor input on the number of employees, reported in the Form M, instead of an index of management and non-management hours worked.

Materials. There is no difference in the way materials input is computed in the original TFP study and the simplified TFP method.

Results of the Simplified TFP Method

Table 8 compares the results from the original Christensen LEC TFP study with the results from the simplified method based on the sample of nine price cap companies included in our original study--Ameritech, Bell Atlantic, BellSouth, GTE, Nynex, Pacific Telesis, Southern New England, Southwestern Bell, and US West. Table 8 shows the annual rates of growth in total output, total input, and TFP. In the original model, LEC TFP was found to grow at an average rate of 2.4 percent per year over the 1984-1993 period and 2.8 percent per year over the 1988-1993 period. Using the original nine companies, the simplified method results in average TFP growth of 2.9 percent per year over the 1984-1993 period and 3.0 percent per year over the 1988-1993 period.

Table 8
Comparison of LEC TFP Growth for Nine Companies in Original Christensen LEC TFP Study:
Original Results Versus Simplified Method
1984-1993

Year	Total Output Original	Total Output Simplified	Total Input Original	Total Input Simplified	TFP Growth Original	TFP Growth Simplified
1984						
1985	2.4%	2.8%	1.3%	0.6%	1.1%	2.2%
1986	3.0%	3.1%	0.2%	0.8%	2.8%	2.3%
1987	3.7%	3.8%	1.9%	1.1%	1.8%	2.7%
1988	5.2%	5.5%	3.1%	2.0%	2.1%	3.5%
1989	4.8%	4.6%	2.7%	2.8%	2.0%	1.8%
1990	3.7%	4.1%	-0.9%	-0.2%	4.6%	4.3%
1991	2.3%	2.4%	1.1%	0.6%	1.2%	1.8%
1992	1.9%	2.3%	-1.6%	-0.9%	3.5%	3.2%
1993	3.6%	4.2%	1.0%	0.1%	2.6%	4.1%
Average Growth						
1984-93	3.4%.	3.6%	1.0%	0.8%	2.4%	2.9%
1988-93	3.3%	3.5%	0.5%	0.5%	2.8%	3.0%

Table 9 shows results for 1988 through 1994 with Lincoln and Sprint added to the sample. The starting year for the simplified study with the expanded sample of companies is 1988 rather than 1984 to eliminate adjustments required to 1984-1987 data because of the Uniform System of Accounts Rewrite (USOAR) that took effect in 1988. The expanded sample also contains results for 1994. Using the expanded sample of companies, the simplified method produces average annual TFP growth of 2.9 percent over the 1988-1993 period.. Over this same period, U.S. economy TFP growth averaged 0.1 percent per year, resulting in a TFP growth differential between the LECs and the U.S. economy of 2.8 percent for the 1988-1993 period. For the 1989-1994 period, LEC TFP growth averaged 3.1 percent per year, U.S. TFP growth averaged 0.3 percent per year, resulting in a TFP growth differential of 2.8 percent.

Table 9
LEC TFP Using the Simplified Method
Results for Expanded Sample of Eleven Price Cap Companies
1988-1994

Year	Total Output Growth	Total Input Growth	TFP Growth
1988			
1989	4.7%	2.9%	1.8%
1990	3.8%	0.0%	3.8%
1991	2.7%	0.7%	2.0%
1992	2.0%	-1.5%	3.5%
1993	4.0%	0.3%	3.7%
1994	3.8%	1.4%	2.4%
Average Growth			
1988-93	3.5%	0.5%	2.9%
1989-94	3.3%	0.2%	3.1%