

1. Local
2. MTS - intrastate
3. MTS - interstate
4. WATS - intrastate
5. WATS - Interstate
6. Private lines - interstate
7. Private lines - intrastate
8. Other toll services
9. Miscellaneous revenues
10. Telegraph services

These revenues are collected for the Bell Operating Companies which report to the FCC and for all independents reporting to the U.S. Telephone Association. These independents represent about 96 percent of all independent telephone company revenues, which in turn are about 20 percent of all local exchange company revenues. Interexchange carriers are identified as AT&T and all (facilities-based) OCCs for which there is public information. Telegraph carrier revenues are drawn from the FCC's Statistics of Communications Common Carriers (SOCCC).

Because there are no separate deflators for private lines or "other toll" revenues that are reliable, all MTS, private lines, and other

3

toll revenues are aggregated into TOTMTS before allocation between interstate and intrastate jurisdictions. The interstate-intrastate split for AT&T is reported to the FCC; however, this split is not available for OCCs or independent telephone companies. The OCC split is assumed to be the same as AT&T after divestiture and constant from 1978 through 1984. Given the small amount of OCC revenues prior to divestiture, this approximation cannot have a serious effect on estimated TFP growth.

The deflators for all services from 1972 through 1988 are the appropriate PPI indexes. Miscellaneous revenues are deflated by the PPI for directory advertising. For 1960-71, there are no PPI indexes; therefore, we are forced to use Bell System indexes as reported by Christensen et al. in their study of Bell System productivity. These deflators do not distinguish between WATS and MTS, requiring us to deflate all toll revenues by the same deflator for 1960-1971.

There are two major adjustments to reported revenues that are required for the post-divestiture period. First, all access expenses have to be deducted from toll revenues to eliminate double counting. This affects OCCs, Bell companies, and independents alike, but it begins in 1978 for OCCs and in 1984 for the rest.

4

Second, an adjustment is made for rental and billing revenues reported by the BOCs and the independent companies. These are revenues derived from the sale of services to the long-distance carriers; therefore, they represent value-added that should be allocated to toll services. Since these revenues are reported as "miscellaneous" revenues, they are reassigned to toll services in proportions determined by AT&T's and the OCCs' distribution of revenues. Then they are deducted from OCC and AT&T revenues in similar proportions.

We use two methods for aggregating the output index. The first, and least theoretically defensible, is simply to aggregate all real revenues in 1977 dollars. The rate of change in output for the TFP calculations in this variant is simply the rate of change in total real revenues.

Two Divisia indexes of individual service real revenue changes were also constructed, one with current revenue-share weights and one with revenue shares adjusted for rate distortions. Since regulators have been distorting rates through the assignment of non-traffic sensitive costs to toll services, it is necessary to adjust revenue shares to attempt to reflect more accurately the incremental cost of service. The amount of NTS shifted to the interstate jurisdiction was estimated from Ottinger and Weinhaus, Behind the Telephone Debates, and from the FCC's Common Carrier Bureau, Office of Industry Analysis. The share of

5

these revenues in all interstate toll was deducted from WATS and TOTMTS revenues and reassigned to local revenues.

The distortion in intrastate toll rates cannot be measured with precision; therefore, we assume that the distortion is equal to that experienced in interstate toll through 1983, but that the distortion recedes more slowly during 1984-88 because intrastate toll rates fall much more slowly than interstate toll rates. The share of total intrastate toll revenues shifted to local service is thus equal to the share shifted for interstate through 1983, but it falls only in proportion to the real decline in intrastate toll rates thereafter. These adjusted revenue shares are then used as the basis for constructing Tornquist weights for a Divisia output index of the six output categories for all telephone companies and the one telegraph output. The annual rates of change in each output index for 1961-88 are shown in Table A-1.

Inputs

One of the most difficult tasks in calculating TFP for the telecommunications sector is the aggregation of inputs for the same domain of suppliers who are captured in the output index. For this

Table A-1. Rates of Output Growth for Alternative Output Indexes - Entire Sector, 1961-88 (%)

Year	Divisia Index (Using Unadjusted Revenue Shares as Weights)	Divisia Index (Using Adjusted Revenue Shares as Weights)	Summed Real Revenues
1961	6.5	6.3	5.6
1962	6.8	6.6	6.6
1963	7.2	7.0	7.0
1964	7.7	7.3	7.5
1965	8.6	8.2	8.3
1966	10.1	9.4	9.8
1967	7.6	7.3	7.5
1968	9.3	8.8	9.1
1969	10.2	9.5	10.0
1970	7.7	7.2	7.6
1971	5.7	5.4	5.7
1972	7.6	7.0	7.6
1973	9.3	8.8	9.3
1974	7.2	6.8	7.2
1975	4.6	4.7	4.6
1976	6.2	6.0	6.3
1977	9.2	9.1	9.3
1978	10.5	9.1	10.4
1979	10.5	9.3	10.5
1980	9.0	8.4	9.1
1981	5.4	4.4	5.5
1982	2.6	2.7	2.8
1983	2.0	1.1	2.3
1984	-1.7	-0.8	-0.4
1985	3.9	2.5	4.7
1986	5.7	4.1	7.0
1987	7.5	5.8	9.1
1988	5.0	4.2	5.7

6

purpose, we utilize data reported by carriers to the FCC and to the USTA as well as annual corporate reports to stockholders of the SEC.

Capital. Capital services are assumed to be proportional to capital stock in the sector. The capital stock series is obtained by the perpetual industry method with the initial gross and net values obtained from BEA's series in the Tangible Wealth in the United States. Capital stock is divided into equipment and structures, and the BEA (straight-line) depreciation rates of 0.072 and 0.0265, respectively, are employed. In addition, we calculate the stock of equipment and structures using declining-balance depreciation. Capital expenditures for each year are divided into structures and equipment per the SOCCC reported allocations. Discards are estimated by using the BEA frequency distribution of discards.

Total capital expenditures are aggregated from the SOCCC, the USTA, and annual corporate reports. These totals are divided into structures and equipment and each series is deflated by the appropriate BEA deflator. In 1984, to adjust for the CPE detariffing, a one-time deduction is made from the perpetual inventory stock of equipment.

Labor. Total employees in the telecommunications sector are obtained by adding reported employees by the local exchange companies and AT&T per the USTA and SOCCC data. OCC employment are estimated

7

from data reported by MCI. Between 1981 and 1987, the total employees were not reported in the SOCCC. As a result, BOC employees are estimated from USTA data for 1982-83, and AT&T employees are obtained from Form M's filed with the FCC. Between 1984 and 1987, all BOC data are obtained from USTA, and AT&T data are obtained from December Administrative MRI reports, also filed with the FCC. The 1988 data are once again available in the SOCCC.

Employee hours are taken from BLS reports on average weekly hours in SIC 481. The BLS hours series is multiplied by the total employee series to obtain the unadjusted labor input.

The unadjusted labor input series is modified for changes in the quality of the work force per Christensen's unpublished paper for 1960-1979. This series is cast forward by estimating a regression of the adjustment on relative telephone wage rates for 1960-79 and using 1980-88 changes in relative wages to forecast the 1980-88 adjustments.

Materials. The only readily-available source of materials inputs for the entire telecommunications sector is the SOCCC data on total costs less expenses for capital services and current labor services. Also excluded are gross receipts taxes. Total capital service expenses include allowances for fixed charges (interest payments), depreciation, and income before taxes. Labor costs are equal to total compensation

8

and benefits per employee from the SOCCC and USTA (including pensions and benefits) times the number of employees. The resulting materials series is adjusted in 1984 for the effect of the one-time write-off of capital equipment on reported capital costs by smoothing the adjustment through 1985. This smoothing affects only the distribution of the productivity gains in 1984 and 1985; not the overall rate of progress. The estimated levels of each input for the entire telephone sector are shown as index numbers in Table A-2.

Weights

Each of the inputs must be weighted in the TFP calculation in proportion to its contribution to total costs. The traditional Tornquist index uses a simple average of beginning and end of-period weights. In this study we use accounting cost shares for these weights. The cost shares are derived from the SOCCC and USTA data, smoothed for the effects of the December 31, 1983 write-offs over the 1983-85 period.

Table A-2. Input Indexes for Entire Sector, 1960-1988 (1977=100)

Year	CAPITAL		Labor	Labor-Adjusted	Materials
	Straight-Line*	Declining-Balance**			
1960	35.5	33.8	75.4	69.4	37.0
1961	37.5	36.0	72.6	67.4	39.4
1962	39.9	38.7	73.2	68.2	41.8
1963	42.4	41.4	74.3	69.6	43.8
1964	45.2	44.5	76.9	72.0	46.7
1965	48.4	48.1	80.2	74.5	49.5
1966	52.0	52.0	85.8	79.1	52.9
1967	55.5	55.6	84.0	77.5	55.2
1968	59.0	59.2	88.3	81.2	57.6
1969	63.2	63.6	96.6	88.0	66.9
1970	68.1	68.9	99.2	90.1	67.0
1971	73.1	74.1	96.4	88.8	70.5
1972	78.0	79.1	100.0	94.0	76.9
1973	83.3	84.7	103.3	97.0	78.4
1974	88.8	90.3	102.5	96.9	80.9
1975	92.6	93.5	97.5	94.2	80.0
1976	96.0	96.4	96.4	94.4	90.3
1977	100.0	100.0	100.0	100.0	100.0
1978	105.0	105.2	106.1	106.2	98.2
1979	110.8	111.4	111.8	111.1	100.5
1980	116.7	117.5	113.2	111.2	107.4
1981	121.9	122.8	114.0	112.4	115.8
1982	125.9	126.2	109.9	108.7	124.9
1983	128.7	128.2	98.8	98.5	121.1
1984	126.8	127.2	92.4	92.1	125.5
1985	130.0	130.5	91.2	91.1	142.6
1986	133.9	134.2	88.6	88.7	149.5
1987	136.6	136.9	87.5	87.3	153.8
1988	140.2	138.4	82.5	81.6	167.5

* 75% Gross Stock + 25% Net Stock.

100% Net Stock.

Alternative TFP Measures

In the text, we report estimates of TFP growth using: (i) variable (Tornquist) weights; (ii) quality-adjusted ("weighted") labor and, (iii) straight-line depreciation. In this appendix, we report a number of alternative estimates, using declining-balance depreciation and unadjusted labor services (Table A-3). While the level of TFP growth varies with the various assumptions employed, the temporal pattern of TFP growth is largely unaffected by these alternative assumptions.

Table A-3. Alternative Estimates of TFP Growth - Entire Sector, 1961 - 1988 (%)

OUTPUT INDEX:	Divisia Unadjusted	Divisia Adjusted	Divisia Unadjusted	Divisia Unadjusted	Summed Real Revenues	Summed Real Revenues
LABOR:	Quality- Adjusted	Quality- Adjusted	Quality- Adjusted	Unadjusted	Quality- Adjusted	Quality- Adjusted
CAPITAL:	Straight Line	Straight Line	Declining Balance	Straight Line	Straight Line	Declining Balance
1961	3.8	3.8	3.4	4.1	3.8	2.8
1962	2.4	2.3	2.8	2.5	2.2	1.8
1963	2.8	2.8	2.4	2.9	2.8	2.3
1964	2.4	1.9	2.8	2.3	2.1	1.8
1965	3.8	2.8	2.8	2.8	2.7	2.4
1966	3.5	2.8	3.1	3.2	3.2	2.9
1967	4.4	4.1	4.2	4.3	4.2	4.1
1968	4.8	3.5	3.9	3.9	3.8	3.8
1969	1.2	8.8	1.1	8.9	1.8	8.9
1970	3.5	3.1	3.3	3.5	3.4	3.2
1971	2.1	1.8	2.8	2.8	2.1	2.8
1972	8.9	8.3	8.9	1.8	8.9	8.9
1973	5.8	4.4	4.9	4.9	5.8	4.9
1974	3.8	3.4	3.8	4.8	3.8	3.8
1975	4.1	4.2	4.4	4.8	4.1	4.4
1976	1.9	1.7	2.2	2.4	2.8	2.3
1977	3.1	3.1	3.3	3.8	3.2	3.3
1978	8.7	5.4	8.7	8.8	8.7	8.8
1979	8.1	4.9	5.9	5.8	8.1	5.9
1980	5.4	4.7	5.2	5.8	5.4	5.3
1981	1.4	8.4	1.5	1.5	1.5	1.8
1982	8.7	8.7	8.9	8.9	8.9	1.8
1983	5.5	4.8	5.7	5.8	5.7	8.8
1984	3.5	-5.8	8.8	8.3	1.7	1.4
1985	-8.1	-1.5	-8.1	-8.1	8.7	8.7
1986	3.9	2.4	3.9	4.8	5.3	5.3
1987	8.3	4.8	8.3	8.2	7.8	7.9
1988	3.1	2.4	3.8	2.9	3.9	4.5