

## EMPLOYMENT

- 1988- **NATIONAL ECONOMIC RESEARCH ASSOCIATES, INC. (NERA)**  
Senior Vice President, Office Head, Telecommunications Practice Director. Dr. Taylor has directed many studies applying economic and statistical reasoning to regulatory, antitrust and competitive issues in telecommunications markets. In the area of environmental regulation, he has studied statistical problems associated with measuring the level and rate of change of emissions.
- 1983-1988 **BELL COMMUNICATIONS RESEARCH, INC. (Bellcore)**  
Division Manager, Economic Analysis, formerly Central Services Organization, formerly American Telephone and Telegraph Company. While at Bellcore, Dr. Taylor performed theoretical and quantitative research focusing on problems raised by the implementation of access charges. His work included design and implementation of demand response forecasting for interstate access demand, quantification of potential bypass liability, design of optimal nonlinear price schedules for access charges and theoretical and quantitative analysis of price cap regulation of access charges.
- 1975-1983 **BELL TELEPHONE LABORATORIES**  
Member, Technical Staff, Economics Research Center. Performed basic research on theoretical and applied econometrics, focusing on small sample theory, panel data and simultaneous equations systems.
- Fall 1977 **MASSACHUSETTS INSTITUTE OF TECHNOLOGY**  
Visiting Associate Professor, Department of Economics. Taught graduate courses in econometrics.
- 1974-1975 **CENTER FOR OPERATIONS RESEARCH AND ECONOMETRICS**  
Université Catholique de Louvain, Belgium.  
Research Associate. Performed post-doctoral research on finite sample econometric theory and on cost function estimation.
- 1972-1975 **CORNELL UNIVERSITY**  
Assistant Professor, Department of Economics. (On leave 1974-1975.) Taught graduate and undergraduate courses on econometrics, microeconomic theory and principles.

## MISCELLANEOUS

- 1985- Journal of Econometrics, North-Holland Publishing Company.  
Associate Editor.

Boards of Directors: National Economic Research Associates, Inc. (1990- ), Episcopal Divinity School, Cambridge, Massachusetts (1995- ).

## TESTIMONIES

William E. Taylor

Exhibit A

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Florida Public Service Commission (Docket No. 820537-TP) on behalf of Southern Bell Telephone and Telegraph Company: economic analysis of premium intraLATA access charges. Filed July 22, 1983.

Arkansas Public Service Commission (Docket No. 83-042-U) on behalf of Southwestern Bell Telephone Company: economic analysis of non-traffic sensitive cost recovery proposals. Filed October 7, 1985.

Florida Public Service Commission (Docket No. 820400-TP) on behalf of Southern Bell Telephone and Telegraph Company: economic principles underlying a proposed method for calculating marginal costs for private lines services. Filed June 25, 1986.

Federal Communications Commission (Docket No. 87-313) on behalf of Bell Communications Research, Inc.: empirical analysis of the United States Telephone Association proposal for price cap regulation of interstate access service, entitled "The Impact of Federal Price Cap Regulation on Interstate Toll Customers." Filed March 17, 1988.

Florida Public Service Commission (Docket No. 880069-TL) on behalf of Southern Bell Telephone and Telegraph Company: economic incentives for firms under the proposed Florida Rate Stabilization Plan. Filed June 10, 1988.

California Public Utilities Commission (Case 88-04-029) on behalf of Pacific Bell: commission payment practices, cross-subsidization of pay telephones, and compensation payments to competitive pay telephone suppliers. Filed July 11, 1988.

Federal Communications Commission (Docket No. 87-313) on behalf of Bell Communications Research, Inc.: empirical analysis of the price cap plan proposed in the FCC Further Notice of Proposed Rulemaking, entitled "The Impact of the FCC Proposed Price Cap Plan on Interstate Consumers." Filed August 18, 1988.

Federal Communications Commission (Docket No. 87-313) on behalf of Bell Communications Research, Inc.: Rebuttal analysis of intervenor comments on "The Impact of the FCC Proposed Price Cap Plan on Interstate Consumers." Filed November 18, 1988.

New Hampshire Public Service Commission (Docket 89-010) on behalf of New England Telephone & Telegraph Company: appropriate level and structure of productivity adjustments in a proposed price regulation plan. Filed March 3, 1989.

Federal Communications Commission (Docket No. 87-313) on behalf of Cincinnati Bell Telephone Company, "Incentive Regulation and Estimates of Productivity," (with J. Rohlf), June 9, 1989.

Delaware Public Service Commission (Docket No. 86-20, Phase II) on behalf of The Diamond State Telephone Company: appropriate costing and pricing methods for a regulated firm facing competition, in connection with a proposed rate reduction. Filed March 31, 1989. Rebuttal testimony filed November 17, 1989.

Federal Communications Commission (Docket No. 87-313) on behalf of the United States Telephone Association: analysis of an AT&T filing and an empirical analysis of productivity growth under price cap regulation, entitled "Analysis of AT&T's Comparison of Interstate Access Charges Under Incentive Regulation and Rate of Return Regulation." Filed as Reply Comments regarding the FCC's Report and Order and Second Further Notice of Proposed Rulemaking in CC Docket 87-313, August 3, 1989.

Federal Communications Commission (Docket No. 87-313) on behalf of Southwestern Bell Telephone Company, "Taxes and Incentive Regulation," filed as Exhibit 3 to the Reply Comments of Southwestern Bell regarding the FCC's Report and Order and Second Further Notice of Proposed Rulemaking in CC Docket 87-313, August 3, 1989.

New York State Public Service Commission (Case 28961 - Fifth Stage) on behalf of New York Telephone Company: appropriate level and structure of productivity adjustments in a proposed price regulation plan. Filed September 15, 1989.

Georgia Public Service Commission (Docket No. 3882-U) on behalf of Southern Bell Telephone and Telegraph Company: analysis of incentive regulation plans. Filed September 29, 1989.

Public Utility Commission of Texas (Docket No. 8585) on behalf of Southwestern Bell Telephone Company: analysis of Texas intrastate switched access charges and bypass of switched access. Filed December 18, 1989.

Federal Communications Commission (Docket 87-313) on behalf of the United States Telephone Association: analysis of appropriate productivity offsets for local exchange carriers in the FCC price cap plan, entitled "Local Exchange Carrier Productivity Offsets for the FCC Price Cap Plan," May 3, 1990.

Federal Communications Commission (Docket 87-313) on behalf of the United States Telephone Association: analysis of appropriate productivity offsets for local exchange carriers in the FCC price cap plan, entitled "Productivity Offsets for LEC Interstate Access," June 8, 1990.

Federal Communications Commission (Docket 87-313) on behalf of the United States Telephone Association: analysis of appropriate productivity offsets for mid-size telephone companies in the FCC price cap plan, entitled "Interstate Access Productivity Offsets for Mid-Size Telephone Companies," June 8, 1990.

State of Maine Public Utilities Commission (Docket No. 89-397) on behalf of New England Telephone & Telegraph Company: theoretical and historical analysis of

incentive regulation in telecommunications, entitled "Incentive Regulation in Telecommunications," filed June 15, 1990.

Illinois Commerce Commission (Docket No. 88-0412) on behalf of Illinois Bell Telephone Company: analysis of pricing issues for public telephone service. Filed August 3, 1990. Rebuttal testimony filed December 9, 1991.

Delaware Public Service Commission (Docket No. 89-24T) on behalf of The Diamond State Telephone Company: rebuttal testimony describing the appropriate costing and pricing methods for the provision of contract Centrex services by a local exchange carrier. Filed August 17, 1990.

Montana Public Service Commission (Docket No. 90.8.46) on behalf of US West Communications: theoretical and historical analysis of incentive regulation plans in telecommunications. Filed October 4, 1990.

Arizona State Air Pollution Control Hearing Board (Docket No. A-90-02) on behalf of Arizona Public Service Company. A statistical study of SO<sub>2</sub> emissions entitled, "Analysis of Cholla Unit 2 SO<sub>2</sub> Compliance Test Data," (October 24, 1990) and an Affidavit (December 7, 1990).

Canadian Radio-Television and Telecommunications Commission (Docket No. 1990-73) on behalf of Bell Canada: "The Effect of Competition on U.S. Telecommunications Performance," (with L.J. Perl). Filed November 30, 1990.

New Jersey Board of Public Utilities (Docket No. TX90050349) on behalf of New Jersey Bell Telephone Company: theoretical and empirical analysis of the Board's intraLATA compensation policy. Filed December 6, 1990.

Federal Communications Commission (Docket 87-313) on behalf of the United States Telephone Association: analysis of total factor productivity calculations, entitled "Productivity Measurements in the Price Cap Docket," December 21, 1990.

Tennessee Public Service Commission (In re: The Promulgation of Agency Statements of General Applicability to Telephone Companies That Prescribe New Policies and Procedures for Their Regulation) on behalf of South Central Bell Telephone Company: theoretical analysis and appraisal of the proposed Tennessee Regulatory Reform Plan. Filed February 20, 1991.

Florida Public Service Commission (Docket No. 900633-TL) on behalf of Southern Bell Telephone and Telegraph Company: alternative measures of cross-subsidization. May 9, 1991.

Federal Communications Commission (Docket 87-313) on behalf of BellSouth Corporation, "The Treatment of New Services under Price Cap Regulation," (with Alfred E. Kahn), June 12, 1991.

Federal Communications Commission (Docket 91-141, In the Matter of Expanded Interconnection with Local Telephone Company Facilities) on behalf of Bell Atlantic, "Effects of Competitive Entry in the U.S. Interstate Toll Markets." August 6, 1991.

California Public Utilities Commission (Phase II of Case 90-07-037) on behalf of Pacific Bell: economic analysis of the effects of FAS 106, (accrual accounting for post-retirement benefits other than pensions) under state price cap regulation, (with Timothy J. Tardiff). Filed August 30, 1991. Supplemental testimony filed January 21, 1992.

Federal Communications Commission (Docket 91-141, In the Matter of Expanded Interconnection with Local Telephone Company Facilities) on behalf of Southwestern Bell, "Economic Effects of the FCC's Tentative Proposal for Interstate Access Transport Services." Filed September 20, 1991.

Rhode Island Public Utilities Commission (Docket No. 1997) on behalf of New England Telephone & Telegraph Company, "Rhode Island Price Regulation Plan," analysis of proposed price regulation plan and evidence of the effects of incentive regulation on prices and infrastructure development. Filed September 30, 1991.

Montana Public Service Commission (Docket No. 90.12.86) on behalf of US West Communications: economic analysis of a proposed incentive regulation plan. Filed November 4, 1991. Additional testimony filed January 15, 1992.

Testimony before the Michigan Circuit Court (Case No. 87-709234-CE and 87-709232-CE) on behalf of Combustion Engineering, Inc., in *Her Majesty the Queen, et al., v. Greater Detroit Resource Recovery Authority, et al., re* statistical analysis of air pollution data to determine emissions limits for the Detroit municipal waste-to-energy facility, February, 1992.

Federal Communications Commission, (Pacific Bell Tariff F.C.C. No. 128, Transmittal No. 1579) on behalf of Pacific Bell, "The Treatment of FAS 106 Accounting Changes Under FCC Price Cap Regulation," (with T.J. Tardiff). Filed April 15, 1992. Reply comments filed July 31, 1992.

New York Public Service Commission (Case No. 28425) on behalf of New York Telephone Company, "Costs and Benefits of IntraLATA Presubscription," (with T.J. Tardiff), filed May 1, 1992.

California Public Utilities Commission, (Docket No. 1.87-11-033), on behalf of Pacific Bell, "The New Regulatory Framework 1990-1992: An Economic Review," (with T.J. Tardiff), filed May 1, 1992.

New Hampshire Public Service Commission, (Docket DE 90-002), on behalf of New England Telephone & Telegraph Company: the appropriate relationship between carrier access and toll prices. Filed May 1, 1992. Reply testimony filed July 10, 1992. Rebuttal testimony filed August 21, 1992.

Delaware Public Utilities Commission, (Docket No. 33), on behalf of Diamond State Telephone Company, "Incentive Regulation of Telecommunications Utilities in Delaware," filed June 22, 1992.

Federal Communications Commission, (CC Docket 92-141, In the Matter of 1992 Annual Access Tariff Filings) on behalf of Bell Atlantic, "Effects of Competitive Entry in the U.S. Interstate Toll Markets: An Update," filed July 10, 1992.

Florida Public Service Commission (Docket No. 920385-TL) on behalf of Southern Bell Telephone and Telegraph Company: the economic relationship between depreciation rates, investment, and infrastructure development. September 3, 1992.

Maryland Public Service Commission (Case No. 8462) on behalf of The Chesapeake and Potomac Telephone Company of Maryland: competition and the appropriate regulatory treatment of Yellow Pages, filed October 2, 1992.

Federal Communications Commission (ET Docket 92-100) on behalf of BellSouth Corporation, "Assigning PCS Spectrum: An Economic Analysis of Eligibility Requirements and Licensing Mechanisms," (with Richard Schmalensee), filed November 9, 1992.

Florida Public Service Commission (Docket No. 920260-TL) on behalf of Southern Bell Telephone and Telegraph Company: economic analysis of a proposed price cap regulation plan. December 18, 1992.

Science, Technology and Energy Committee of the New Hampshire House of Representatives on behalf of New England Telephone Company, "An Economic Perspective on New Hampshire Senate Bill 77," an analysis of resale of intraLATA toll services. April 6, 1993

California Public Utilities Commission, (Docket No. I.87-11-033), on behalf of Pacific Bell, "Pacific Bell's Performance Under the New Regulatory Framework: An Economic Evaluation of the First Three Years," (with T.J. Tardiff), filed April 8, 1993, reply testimony filed May 7, 1993.

Canadian Radio-Television and Telecommunications Commission (Docket No. 92-78) on behalf of Alberta General Telephone: "Lessons for the Canadian Regulatory Structure from the U.S. Experience with Incentive Regulation," and "Performance Under Alternative Forms of Regulation in the U.S. Telecommunications Industry," (with T.J. Tardiff). Filed April 13, 1993.

Federal Communications Commission (Petition for Declaratory Ruling and Related Waivers to Establish a New Regulatory Model for the Ameritech Region) on behalf of Ameritech: "Price Cap Regulation and Enhanced Competition for Interstate Access Services," filed April 16, 1993, Reply Comments, July 12, 1993.

Delaware Public Utilities Commission, (Docket No. 33), on behalf of Diamond State Telephone Company, "Reply Comments," June 1, 1993, "Supplementary Statement," June 7, 1993, "Second Supplementary Statement," June 14, 1993: analysis of productivity growth and a proposed incentive regulation plan.

Federal Communications Commission (Amendment of Part 90 of the Commission's Rules to Adopt Regulations for Automatic Vehicle Monitoring Systems) PR Docket No. 93-61 on behalf of PacTel Teletrac, "The Economics of Co-Channel Separation for Wideband Pulse Ranging Location Monitoring Systems," (with R. Schmalensee), filed June 29, 1993.

Vermont Public Service Board, Petition for Price Regulation Plan of New England Telephone on behalf of New England Telephone Company, Dockets 5700/5702: analysis of appropriate parameters for a price regulation plan, filed September 30, 1993, rebuttal testimony July 5, 1994.

Pennsylvania Public Utility Commission, (Docket No. P-009350715): a study of inflation offsets in a proposed price regulation plan, filed October 1, 1993, rebuttal testimony filed January 18, 1994.

New Jersey Board of Regulatory Commissioners, (Docket No. TX93060259), Affidavit analyzing statistical evidence regarding the effect of intraLATA competition on telephone prices, filed October 1, 1993.

Federal Communications Commission (In the Matter of Policy and Rules Concerning Rates for Competitive Common Carrier Services and Facilities Authorization Therefor) on behalf of four Regional Bell Holding Companies, Affidavit "Interstate Long Distance Competition and AT&T's Motion for Reclassification as a Nondominant Carrier," filed November 12, 1993, (with A.E. Kahn).

Maryland Public Service Commission (Case No. 8584) on behalf of The Chesapeake and Potomac Telephone Company of Maryland: appropriate pricing and regulatory treatment of interconnection to permit competition for local service, filed November 19, 1993, (with A.E. Kahn), rebuttal testimony filed January 10, 1994, surrebuttal testimony filed January 24, 1994.

Testimony before the United States District Court, Eastern District of New York on behalf of Jancyn Manufacturing Corp., in *Jancyn Manufacturing Corp. v. The County of Suffolk*. Commercial damages. Depositions: September 19, 1991, November 22, 1993; Testimony and Cross-Examination: January 11, 1994.

Affidavit to the U.S. District Court for the District of Columbia on behalf of Bell Atlantic Corporation in *United States of America v. Western Electric Company, Inc. and American Telephone and Telegraph Company*, re relief from the interLATA restrictions of the MFJ in connection with the pending merger with Tele-Communications, Inc. and Liberty Media Corporation, filed January 14, 1994, (with A.E. Kahn).

New Jersey Board of Public Utilities (Docket Nos. TX90050349, TE92111047, TE93060211) on behalf of Bell Atlantic-New Jersey: economic impacts of intraLATA toll competition and regulatory changes required to accommodate competition, filed April 7, 1994. Rebuttal testimony filed April 25, 1994. Summary Affidavit and Technical Affidavit filed April 19, 1994.

Massachusetts Department of Public Utilities (Docket No. D.P.U. 94-50), on behalf of NYNEX: analysis of appropriate parameters for a price regulation plan, filed April 14, 1994, rebuttal testimony filed October 26, 1994.

Federal Communications Commission (CC Docket 94-1) on behalf of the United States Telephone Association: "Economic Performance of the LEC Price Cap Plan," filed as Attachment 5 to the United States Telephone Association Comments, May 9, 1994, "Economic Performance of the LEC Price Cap Plan: Reply Comments," filed as Attachment 4 to the United States Telephone Association Reply Comments, June 29, 1994.

Federal Communications Commission (CC Docket 94-1) on behalf of the United States Telephone Association: "Comments on the USTA Pricing Flexibility Proposal," filed as Attachment 4 to the United States Telephone Association Comments, May 9, 1994, "Reply Comments: Market Analysis and Pricing Flexibility for Interstate Access Services," filed as Attachment 3 to the United States Telephone Association Reply Comments, June 29, 1994 (with Richard Schmalensee).

Affidavit to the U.S. District Court for the District of Columbia on behalf of Southwestern Bell in *United States of America v. Western Electric Company, Inc. and American Telephone and Telegraph Company*, regarding provision of telecommunications and information services across LATA boundaries outside the regions in which its local exchange operations are located, filed May 13, 1994, (with A.E. Kahn).

Federal Communications Commission (File Nos. W-P-C 6912 and 6966) on behalf of Bell Atlantic Corporation, affidavit supporting Section 214 applications to provide video dialtone services, August 5, 1994.

Affidavit to the U.S. Department of Justice on behalf of NYNEX in *United States of America v. Western Electric Company, Inc. and American Telephone and Telegraph Company*, regarding provision of telecommunications services across LATA boundaries for traffic originating or terminating in New York State, filed August 25, 1994.  
Federal Communications Commission (File Nos. W-P-C 6982 and 6983) on behalf of NYNEX: affidavit supporting Section 214 applications to provide video dialtone services in Massachusetts and Rhode Island, September 21, 1994.

New York State Public Service Commission (Case 92-C-0665, Proceeding on Motion of the Commission to Investigate Performance-Based Incentive Regulatory Plans for New York Telephone Company) on behalf of New York Telephone Company: appropriate level and structure of productivity adjustments and competitive pricing safeguards in a proposed incentive regulation plan. Filed as part of panel testimony, October 3, 1994.

Delaware Public Utilities Commission, (Docket No. 42), on behalf of Bell Atlantic - Delaware, rebuttal testimony concerning the historical effects of equal access competition in interstate toll markets and the likely future effects of competition under 1+ presubscription in Delaware, filed October 21, 1994.

Maryland Public Service Commission (Case No. 8659) on behalf of Bell Atlantic - Maryland: appropriate pricing of interconnection among competing local exchange carriers, filed November 9, 1994.

Pennsylvania Public Utility Commission, (Docket No. I-940034): issues regarding proposed presubscription for intraLATA toll traffic in Pennsylvania, including the likely demand effects of 1+ presubscription and the role of economically efficient imputation of carrier access charges. Filed as part of panel testimony, December 8, 1994. Reply testimony filed February 23, 1995. Surrebuttal testimony filed March 16, 1995.

State of Maine Public Utilities Commission (Docket Nos. 94-123/94-254) on behalf of New England Telephone & Telegraph Company: analysis of appropriate parameters for a price regulation plan, filed December 13, 1994, rebuttal testimony filed January 13, 1995.

Maryland Public Service Commission (Case No. 8584, Phase II) on behalf of Bell Atlantic - Maryland: geographically deaveraged incremental and embedded costs of service, filed December 15, 1994, additional direct testimony concerning efficient rate structures for interconnection pricing, May 5, 1995, rebuttal testimony filed June 30, 1995.

Canadian Radio-Television and Telecommunications Commission (Application of Teleglobe Canada for Review of the Regulatory Framework of Teleglobe Canada Inc.): on behalf of Teleglobe Canada, Inc., structure of a price regulation plan for the franchised supplier of overseas telecommunications services in Canada. Filed December 21, 1994.

Canadian Radio-Television and Telecommunications Commission, Response to Interrogatory SRCI(CRTC) 1Nov94-906, "Economies of Scope in Telecommunications," on behalf of Stentor. Filed January 31, 1995.

Canadian Radio-Television and Telecommunications Commission, Implementation of Regulatory Framework and Related Issues, Telecom Public Notices CRTC 94-52, 94-56 and 94-58, "Economic Welfare Benefits from Rate Rebalancing," on behalf of Stentor. Filed February 20, 1995.

Federal Communications Commission on behalf of Bell Atlantic Corporation, affidavit examining cost support for Asymmetric Digital Subscriber Loop (ADSL) video dialtone market trial. Filed February 21, 1995.

Federal Communications Commission on behalf of Bell Atlantic Corporation, affidavit examining cost support for Bell Atlantic's video dialtone tariff. Filed March 6, 1995.

Federal Communications Commission on behalf of the United States Telephone Association, study entitled "Competition in the Interstate Long-Distance Markets: Recent Evidence from AT&T Price Changes," *ex parte* filing in CC Docket No. 94-1, March 16, 1995.

Public Service Commission of West Virginia (Case No. 94-1103-T-GI) on behalf of Bell Atlantic - West Virginia: economic analysis of issues regarding proposed presubscription for intraLATA toll traffic in West Virginia, March 24, 1995.

Kentucky Public Service Commission on behalf of South Central Bell Telephone Company, testimony concerning telecommunications productivity growth and price cap plans, April 18, 1995.

Federal Communications Commission (CC Docket No. 79-252) on behalf of Bell Atlantic, BellSouth, SBC, and Pacific Telesis, "An Analysis of the State of Competition in Long-Distance Telephone Markets," study attached to *ex parte* comments examining the competitiveness of interstate long-distance telephone markets, (with J. Douglas Zona), April 1995.

California Public Utilities Commission, (U 1015 C) on behalf of Roseville Telephone Company, testimony regarding productivity measures in Roseville's proposed new regulatory framework, filed May 15, 1995, rebuttal testimony filed January 12, 1996.

Massachusetts Department of Public Utilities (Docket No. D.P.U. 94-185) on behalf of NYNEX: economic analysis of terms and conditions for efficient local competition, filed May 19, 1995, rebuttal testimony filed August 23, 1995.

Affidavit to the U.S. Department of Justice on behalf of SBC Communications Inc. in *United States of America v. Western Electric Company, Inc. and American Telephone and Telegraph Company*, regarding Telefonos de Mexico's (Telmex's) provision of interexchange telecommunications services within the United States, filed May 22, 1995.

The Public Utilities Commission of Ohio (Case No. 94-1695-TP-ACE) on behalf of Cincinnati Bell Telephone Company: economic analysis of terms and conditions for efficient local competition, filed May 24, 1995.

Affidavit to the U.S. Department of Justice on behalf of SBC Communications Inc. in *United States of America v. Western Electric Company, Inc. and American Telephone and Telegraph Company*, regarding provision of interexchange telecommunications services to customers with independent access to interexchange carriers, filed May 30, 1995.

The New Jersey Board of Public Utilities (Docket No. TX94090388) on behalf of Bell Atlantic - New Jersey: economic analysis of issues regarding proposed presubscription for intraLATA toll traffic in New Jersey. Amended direct testimony filed April 17, 1995. Rebuttal Testimony filed May 31, 1995.

Vermont Public Service Board, (Open Network Architecture Docket No. 5713) on behalf of New England Telephone Company, economic principles for local competition, interconnection and unbundling, direct testimony filed June 7, 1995, rebuttal testimony filed July 12, 1995.

State of Connecticut, Department of Public Utility Control, (DPUC Docket No. 95-03-01) on behalf of Southern New England Telephone Company, testimony concerning productivity growth targets in a proposed state price cap regulation plan, filed June 19, 1995.

Federal Communications Commission (File Nos. W-P-C 7074) on behalf of Southern New England Telephone Company, affidavit supporting Section 214 applications to provide video dialtone services, July 6, 1995.

Louisiana Public Service Commission (Docket No. U-17949, Subdocket E) on behalf of South Central Bell Telephone Company, rebuttal testimony concerning productivity growth accounting and other aspects of a price regulation plan, July 24, 1995.

New York Public Service Commission (Case 94-C-0017) on behalf of New York Telephone Company, testimony competition and market power in intrastate toll markets, filed August 1, 1995.

Louisiana Public Service Commission (Docket No. U-20883, Subdocket A) on behalf of South Central Bell Telephone Company, rebuttal testimony concerning methods for measuring the cost of providing universal service, August 16, 1995.

*US WATS v. AT&T*: Retained by counsel for US WATS, a reseller of AT&T long distance services, plaintiff in an antitrust suit alleging monopolization and conspiracy in business long distance markets. Antitrust liability and damages. Confidential Report, August 22, 1995. Depositions September 30, October 1, October 12, December 3, 1995. Testimony October 18-20, 25-27, 30, 1995. Rebuttal testimony December 4, December 11, 1995.

California Public Utilities Commission, (Investigation No. I.95-05-047), on behalf of Pacific Bell, "Incentive Regulation and Competition: Issues for the 1995 Incentive Regulation Review," (with R.L. Schmalensee and T.J. Tardiff), filed September 8, 1995, reply testimony filed September 18, 1995.

Mississippi Public Service Commission (Docket No. 95-UA-313) on behalf of BellSouth Telecommunications, Inc. d/b/a South Central Bell Telephone Company, rebuttal testimony addressing cost issues, as they pertain to price regulation raised in the direct testimony by intervenors. Filed October 13, 1995.

Mexican Secretariat of Communications and Transport on behalf of Southwestern Bell International Holdings Corporation, affidavit on interconnection regulation (with T.J. Tardiff). Filed October 18, 1995.

Tennessee Public Service Commission (Docket No. 95-02499) on behalf of BellSouth Telecommunications, Inc. d/b/a BellSouth Telephone Company, testimony addressing the definition and measurement of the cost of supplying universal service. (direct testimony October 20, 1995, rebuttal testimony October 25, 1995). Additional testimony regarding economic principles underlying the creation of a competitively-neutral universal service fund: direct testimony October 30, 1995, rebuttal testimony November 3, 1995).

Federal Communications Commission (CC Docket No. 95-145) on behalf of Bell Atlantic Corporation, affidavit examining economic issues raised in the investigation of Bell Atlantic's video dialtone tariff, filed October 26, 1995. Supplemental Affidavit filed December 21, 1995.

New England Telephone and Telegraph Company, D/B/A NYNEX, State of Rhode Island (Docket No. 2252), testimony addressing the economic conditions under which competition in the local exchange and intraLATA markets will bring benefits to customers. Direct testimony, November 17, 1995.

Louisiana Public Service Commission (Docket No. U-17949, Subdocket E) on behalf of South Central Bell Telephone Company, supplemental and rebuttal testimony concerning economic issues in depreciation accounting in the presence of competition and price cap regulation, November 17, 1995. Surrebuttal testimony, December 13, 1995, further surrebuttal testimony, January 12, 1996.

*Darren B. Swain, Inc. d/b/a U.S. Communications v. AT&T Corp.*, United States District Court for the Northern District of Texas, Dallas Division, Civil Action 394CV-1088D: Retained by counsel for U.S. Communications, a reseller of AT&T long distance services, plaintiff in an antitrust suit alleging monopolization in inbound business long distance markets. Antitrust liability and damages. Confidential Report, November 17, 1995.

Louisiana Public Service Commission (Docket No. U-20883) on behalf of South Central Bell Telephone Company, "Price Regulation and Local Competition in Louisiana," affidavit evaluating a framework for local competition and price regulation in Louisiana, November 21, 1995.

## PUBLICATIONS

"Smoothness Priors and Stochastic Prior Restrictions in Distributed Lag Estimation," International Economic Review, 15 (1974), pp. 803-804.

"Prior Information on the Coefficients When the Disturbance Covariance Matrix is Unknown," Econometrica, 44 (1976), pp. 725-739.

"Small Sample Properties of a Class of Two Stage Aitken Estimators," Econometrica, 45 (1977), pp. 497-508.

"The Heteroscedastic Linear Model: Exact Finite Sample Results," Econometrica, 46 (1978), pp. 663-676.

"Small Sample Considerations in Estimation from Panel Data," Journal of Econometrics, 13 (1980) pp. 203-223.

"Comparing Specification Tests and Classical Tests," Bell Laboratories Economics Discussion Paper, 1980 (with J.A. Hausman).

"Panel Data and Unobservable Individual Effects," Econometrica, 49 (1981), pp. 1377-1398 (with J.A. Hausman).

"On the Efficiency of the Cochrane-Orcutt Estimator," Journal of Econometrics, 17 (1981), pp. 67-82.

"A Generalized Specification Test," Economics Letters, 8 (1981), pp. 239-245 (with J.A. Hausman).

"Identification in Linear Simultaneous Equations Models with Covariance Restrictions: An Instrumental Variables Interpretation," Econometrica, 51 (1983), pp. 1527-1549 (with J.A. Hausman).

"On the Relevance of Finite Sample Distribution Theory," Econometric Reviews, 2 (1983), pp. 1-84.

"Universal Service and the Access Charge Debate: Comment," in P.C. Mann and H.M. Trebbing (editors) Changing Patterns in Regulation, Markets, and Technology: The Effect on Public Utility Pricing. The Institute of Public Utilities, Michigan State University, 1984.

"Recovery of Local Telephone Plant Costs under the St. Louis Plan," in P.C. Mann and H.M. Trebbing (editors) Impact of Deregulation and Market Forces on Public Utilities. The Institute of Public Utilities, Michigan State University, 1985.

"Access Charges and Bypass: Some Approximate Magnitudes," in W.R. Cooke (editor) Proceedings of the Twelfth Annual Telecommunications Policy Research Conference, 1985.

"Federal and State Issues in Non-Traffic Sensitive Cost Recovery," in Proceedings from the Telecommunications Deregulation Forum, Karl Eller Center, College of Business and Public Administration, University of Arizona, Tucson, Arizona, 1986.

"Panel Data" in N.L. Johnson and S. Kotz (editors), Encyclopedia of Statistical Sciences, John Wiley & Sons, New York, 1986.

"An Analysis of Tapered Access Charges for End Users," in P.C. Mann and H.M. Trebbing (editors) New Regulatory and Management Strategies in a Changing Market Environment. The Institute of Public Utilities, Michigan State University, 1987 (with D.P. Heyman, J.M. Lazorchak, and D.S. Sibley).

"Efficient Estimation and Identification of Simultaneous Equation Models with Covariance Restrictions," Econometrica, 55 (1987), pp. 849-874 (with J.A. Hausman and W.K. Newey).

"Alternative NTS Recovery Mechanisms and Geographic Averaging of Toll Rates," in Proceedings of the Thirteenth Annual Rate Symposium: Pricing Electric, Gas, and Telecommunications Services. The Institute for the Study of Regulation, University of Missouri, Columbia, 1987.

"Price Cap Regulation: Contrasting Approaches Taken at the Federal and State Level," in W. Bolter (editor), Federal/State Price-of-Service Regulation: Why, What and How?, Proceedings of the George Washington University Policy Symposium, December, 1987.

"Local Exchange Pricing: Is There Any Hope?," in J. Alleman (editor), Perspectives on the Telephone Industry: The Challenge of the Future, Ballinger Publishing Company, Cambridge, Massachusetts, 1989.

"Generic Costing and Pricing Problems in the New Network: How Should Costs be Defined and Assessed," in P.C. Mann and H.M. Trebbing (editors) New Regulatory Concepts, Issues, and Controversies. The Institute of Public Utilities, Michigan State University, 1989.

"Telephone Penetration and Universal Service in the 1980s," in B. Cole (editor), Divestiture Five Years Later, Columbia University Press, New York, New York, 1989, (with L.J. Perl).

"Regulating Competition for IntraLATA Services," in Telecommunications in a Competitive Environment, Proceedings of the Third Biennial NERA Telecommunications Conference, 1989, pp. 35-50.

"Costing Principles for Competitive Assessment," in Telecommunications Costing in a Dynamic Environment, Bellcore-Bell Canada Conference Proceedings, 1989 (with T.J. Tardiff).

"Optional Tariffs for Access in the FCC's Price Cap Proposal," in M. Einhorn (ed.), Price Caps and Incentive Regulation in the Telecommunications Industry, Kluwer, 1991 (with D.P. Heyman and D.S. Sibley).

"Alternative Measures of Cross-Subsidization," prepared for the Florida Workshop on Appropriate Methodologies for the Detection of Cross-Subsidies, June 8, 1991.

"Predation and Multiproduct Firms: An Economic Appraisal of the Sievers-Albery Results," Antitrust Law Journal, 30 (1992), pp. 785-795.

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## HISTORICAL PRODUCTIVITY GROWTH IN THE U.S. TELECOMMUNICATIONS INDUSTRY

### A. Introduction

To set a reasonable productivity target, we should know the historical difference between the total factor productivity (TFP) growth of the telecommunications industry and the TFP growth of U.S. industry as a whole. There are two distinct ways to calculate this differential: direct studies and indirect studies. Direct studies attempt to measure the TFP of the U.S. economy and the telecommunications industry directly and then calculate the difference to obtain the productivity differential. Indirect studies rely on the economic theory of duality which allows that the difference between the TFP growth of the U.S. as a whole and the telecommunications industry can be calculated as the difference in the rate of growth of their output prices. Whether the differential is calculated using direct or indirect methods, the result is the same: telecommunications productivity grows approximately 2 percent faster than productivity for U.S. industry as a whole.

### B. Direct Studies of the Productivity Differential

#### 1. TFP Growth for U.S. Industry as a Whole Averages About 1 Percent

There are several independent estimates of the historical rate of productivity change for U.S. industry. Such TFP studies are routinely performed by government agencies (the Bureau

of Labor Statistics), academic economists, independent research organizations (the American Productivity and Quality Center), and—before divestiture—AT&T. Long run productivity change for the telecommunications industry and for the U.S. as a whole has varied slowly over time, so that an accurate estimate of the average difference between productivity for the industry and for the economy can be obtained from historical data. As shown in Figure B.1, a ten year moving average of annual productivity change for U.S. industry as measured by (i) the Bureau of Labor Statistics (BLS), (ii) the American Productivity and Quality Center (formerly the American Productivity Center, abbreviated APC), (iii) Jorgenson, Gollop, and Fraumeni (JGF), and (iv) L. R. Christensen (of the University of Wisconsin, abbreviated LRC) generally varies between 0 percent and 3 percent. For the entire periods that the indices are available, annual productivity growth averaged 1.3 percent (as measured by the BLS from 1948-1992), 1.7 percent (as measured by the APC from 1948-1987), 0.8 percent (as measured by JGF from 1948-1979), and 1.2 percent (as measured by LRC from 1952-1987).

## 2. TFP Growth for the Telecommunications Industry Averages About 3 Percent

Several studies show that the long run average productivity change for the telecommunications industry has varied slowly over time but at a higher rate—generally between 2 percent and 6 percent per year. This does not mean that a reasonable productivity target for a price cap plan is between 2 and 6 percent. We must subtract the growth of U.S. Total Factor Productivity from the telecommunications industry TFP to obtain the historical productivity target. Figure B.2 shows ten year average productivity changes for various definitions of the

telecommunications industry: (i) APC, as calculated for the *communications industry*, (ii) AT&T and L. R. Christensen (abbreviated LRC(1)) for the *Bell System*, (iii) Christensen (LRC(2)) and R. W. Crandall of the Brookings Institution (RWC) for the *U.S. telecommunications industry*, (iv) JGF for *telephone, telegraph and miscellaneous communications*, and (v) Christensen (LRC(3)) for the post-divestiture *LEC industry* (because only 8 years are available, the average for those 8 years is presented as a square point in the figure). The APC study includes broadcasting which is not included in the LRC(2), LRC(3), RWC or JGF studies.

The most recent study of telecommunications TFP by Christensen (LRC(3)) reinforces the point that productivity in the telecommunications sector since 1984 is fully consistent with the history of telecommunications TFP for comparably long periods since 1947. As shown on Table B.1, for the periods that the indices are available, annual productivity growth averaged between 4.0 and 2.6 percent. Table B.1 also shows TFP calculations for aggregate U.S. industry.

### 3. The Historical Productivity Differential Averages Approximately 2 Percent

For the studies outlined above, the estimated telephone productivity differentials are shown in Figure B.3, using 10 year averages for each of the estimates of the productivity differential. The APC, LRC(2), and JGF estimates represent the difference between APC, LRC(2), and JGF estimates of TFP growth rates for both the telecommunications industry and the total U.S. industry. LRC(1), AT&T, and RWC are the difference between the respective measures of telecommunications industry TFP and the BLS measure of U.S. TFP. The LRC(3) differential is presented as a point which represents the difference between the average growth rate

of LEC industry TFP over the 8 year period 1984-1992 and U.S. TFP average growth over the same period. Measures of the differential at the most recent possible date are presented in Table B.2, based on productivity growth over the entire period. AT&T and Dr. Christensen both present average differentials (between the Bell System TFP and unpublished studies of the U.S. as a whole) for the 1948-1979 period, and these are noted in Table B.2.

Two additional TFP studies corroborate the productivity differential estimates in Figure B.3. A 1981 study by M. A. Nadiri and M. A. Schankerman (of New York University and the National Bureau of Economic Research) calculates an average rate of growth of TFP for the Bell System of 4.09 percent from 1947 to 1976 which yields a differential of 2.1 percent when compared with the comparable time period as measured by the BLS. For this particular period, the APC, AT&T, and LRC(1) differentials averaged 2.6 percent, 1.2 percent, and 1.1 percent respectively. A March 1993 study by DRJ/McGraw-Hill estimates an annual growth of a Leontief index of TFP for *telecommunications (less broadcasting)* of 3.0 percent between 1963 and 1991. A comparable estimate in the same study of the change in U.S. TFP over the period is 0.2 percent, so that the estimated differential is 2.8 percent.

To interpret the different studies, recall that the APC compares U.S. industry with the *communications industry* (including broadcasting and miscellaneous communications), AT&T and LRC(1) refer to the *Bell System*, and LRC(2), RWC, and JGF's analysis applies to the *telecommunications industry*.

Note that in Figure B.3, the point representing the differential between Christensen's most recent study of *LEC industry* TFP and the U.S. TFP is consistent with comparably long

periods since 1948 which strengthens the conclusion that the long run productivity differential is about 2 percent. In summary, the differential between telecommunications and U.S. productivity growth has averaged about 2 percent for at least the past *forty-five* years.

C. Indirect Measures of the Productivity Differential Yield the Same Result as Direct Studies: A Differential of About 2 Percent

A second method of calculating the differential total factor productivity for an industry is based on the rate of change of output prices relative to input prices for a particular industry and for the U.S. economy as a whole. The economic theory of duality implies that the difference in TFP growth between the telecommunications industry and the nation as a whole can be calculated from the difference in their output price growth rates, adjusted for exogenous cost change differences.

Table B.3 presents various estimates of the telecommunications productivity differential, using the consumer price index (CPI-U) and the GNP price index (GNP-PI) as measures of the change in national output prices and the CPI total telephone price index (CPI-U Total Telephone) as a measure of the change in telecommunications output prices. The differential based on GNP-PI as the index of U.S. national output prices is significantly lower than that based on the CPI-U, at least for recent periods. Although there is some variation in all estimates over different time periods, the data are consistent with an average differential of about 2 percent. Of particular interest are the long-run estimates of the productivity differential in the study by Spavins and Lande. The Spavins-Lande study reported a differential of 1.7 percent from

1929-1987. My analysis of their data updated through 1993 yields a differential of 1.6 percent over the period 1929-1993.

Figure B.4 shows the long run productivity differential based on the difference between the CPI-U index and the CPI total telephone price index (CPI-U Total Telephone). The average differential is 1.6 percent. Figure B.5 shows the same calculation using the GNP-PI deflator and the CPI total telephone price index. The average differential here is 1.7 percent.

State price cap regulation for a LEC does not generally encompass all of the LECs' services: the price cap is always limited to intrastate services and is frequently applied only to non-competitive services. We have developed two alternative measures of the productivity differential: one for local service and one for the combination of local and intrastate toll services. An estimate of the long run productivity differential for *local service* and for *local and intrastate toll services combined* is shown in Figure B.6. Also shown in Figure B.6 is the average differential for all telephone services (1.7 percent) from Figure B.5. The historical average differential for *local and intrastate toll services* (plotted as GNP-PI - LEC INDEX) is 0.7 percent and the historical average differential for *local service* (GNP-PI - CPI LOCAL) is even lower, -0.7 percent. Both have been estimated for the longest period for which GNP-PI data is available.

An alternative interpretation of these results is that—irrespective of productivity growth—the difference between national inflation and total telephone service prices is a measure of the real rate of price changes that telephone customers have experienced over the period. Thus averaged over the past ten years, U.S. telephone customers have encountered a rate of real price decrease of approximately 1.7 percent per year. However, local service prices have not fallen at

that rate; local service prices have actually increased by about 0.7 percent per year in real terms.

Several different indirect studies of the difference between telecommunications industry TFP growth and U.S. industry TFP growth confirm that the differential has been about 2 percent for at least the past *sixty-five* years and that this conclusion is also supported over any sufficiently long period of time.

D. Volatility of the Productivity Differential Demands Sufficiently Long Periods of Analysis

True productivity growth for a firm, an industry, or the U.S. as a whole varies a great deal from year to year because of productivity-increasing or productivity-decreasing activities that occur less frequently than once per year. For example, suppose every five years, a firm undergoes a significant restructuring in which redundant workers and managers are eliminated from the payroll. Measured productivity growth from this source would show no change in four years out of five and a productivity increase in the fifth year that was roughly five times its long run annual rate. Obviously if this source of productivity growth were important, productivity measurement averaged over less than a five year period would yield a serious bias.

In Figure B.7, annual change in U.S. TFP is shown, and it is clear from the plot of *annual* TFP change that growth estimates from one or two years can seriously misstate the long run average TFP change at any point in time. Using J. Kendrick's estimates of U.S. TFP change from 1884 to 1969, the picture that emerges is that the volatility of TFP change exceeds that of the U.S. business cycle, and that the average frequency of the TFP growth cycle over this period

is about 3 years.<sup>1</sup> For statistical purposes then, a 3 year period (a complete cycle) should be treated as a single observation, and multiple 3 year periods--i.e., a minimum of 6 years--must be observed to calculate a meaningful average productivity measure with any degree of precision.

This requirement, coupled with the need to average out the effects of a single company's erratic changes in TFP, require that a large sample of the telecommunications industry is reviewed over a long period of time. Figure B.8 shows annual and five and ten year averages of telecommunications TFP growth. Finally, it is only the difference between national and industry TFP growth that matters for the productivity target in the price cap formula. Figure B.9 shows considerable variation in annual productivity differences, ranging from +6.6 to -5.4 percent per year. The differences in the ten-year moving average are much less extreme ranging from a maximum of +3.5 and a minimum of 0.5 percent.

The picture in Figure B.9 also shows clearly that the long-run productivity differential between the U.S. telephone industry and U.S. private business averages about 2 percent per year. We observed this same fact earlier in Figure B.5, where we noted that the difference between the annual rate of growth of GNP-PI and the CPI-U total telephone price index was 1.7 percent.<sup>2</sup> This same differential (approximately 2 percent) has been observed by most students of telecommunications productivity; possibly its strongest statement was provided by the FCC staff

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<sup>1</sup> Thus annual growth in TFP rises and falls more rapidly than annual growth in GNP, averaging about 3 years between peaks or between troughs. J. W. Kendrick, *Long Term Economic Growth 1860-1970* (Washington D.C.: U.S. Bureau of the Census, June 1973).

<sup>2</sup> An important duality principle in the economic theory of production assures us that we can use relative growth rates of input and output prices or quantities to estimate relative growth rates in TFP. See, for example, D. W. Jorgenson, "The Embodiment Hypothesis," *The Journal of Political Economy* (February 1966), pp. 1-17.

in the federal price cap docket where they noted a constant productivity differential (using output prices) of between 1.7 and 2 percent over the 1929-1989 period.<sup>3</sup>

These results suggest that the price cap would be too volatile to be practical, if the productivity target were adjusted every year based on annual productivity growth. Moreover, if a company's own productivity growth were used to establish the productivity target, the incentive basis of the price cap formula would degenerate. A plan in which a company's TFP growth this year determines its price growth next year would be perilously close to ordinary rate of return regulation based on an historic test year. To obtain the full benefit of incentives to increase productivity growth and achieve the highest possible dynamic efficiency, the productivity target must be *fixed* (i.e., constant over time), so that the firm will treat it as independent of any of its actions.

E. A 2 Percent Differential is Consistent with the FCC Productivity Target

Our historical TFP differential is consistent with the productivity target used by the FCC in its price cap plan for local exchange carrier interstate services. The FCC has implemented a productivity offset of 3 percent in its price regulation plan for AT&T and 3.3 percent for its price regulation plan for the interstate access services of the LECs. (A LEC may

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<sup>3</sup> Supplemental Notice of Proposed Rulemaking, CC Docket 87-313 (released March 12, 1990), Appendix D, "Total Telephone Productivity in the Pre and Post Divestiture Periods," by T. C. Spavins and J. M. Lande; and Second Report and Order, CC Docket 87-313 (released October 4, 1990), Appendix D, "The Long Term View of the Appropriate Productivity Factor for Interstate Exchange Access," by T. C. Spavins.

select a productivity offset of 4.3 percent in exchange for a more favorable sharing proportion for earnings above 12.25 percent.) The FCC's adoption of 3 percent as a productivity offset for AT&T derives primarily from its analysis of AT&T's post-divestiture output prices (Further Notice of Proposed Rulemaking, CC Docket 87-313, released May 23, 1988, Appendix C), in which AT&T's MTS prices were shown to have grown approximately 2.48 percent more slowly than the GNP-PI over the post-divestiture period. An explicit "consumer productivity dividend" of 0.5 percent was added to the historical AT&T productivity differential to insure that ratepayers benefitted from the regulatory change.

The productivity offset of 3.3 percent for LECs in the price cap plan reflects several factors which do not apply to intrastate service. First, interstate demand is almost entirely driven by toll traffic and growth in interstate toll traffic, stimulated by lower toll rates, is significantly greater than the growth of intrastate toll or local service. Second, the 3.3 percent offset is specific to the LEC price cap plan, and its value is very sensitive to details such as the treatment of common line demand in the price cap formula. Finally, Appendix D to the Second Report and Order in CC Docket 87-313 showed that a long run productivity differential for the total industry of 1.7 to 2.0 percent would imply an interstate productivity differential of 2.1 to 2.6 percent and an associated intrastate productivity differential of 1.57 to 1.81 percent: T. C. Spavins, "The Long Term View of the Appropriate Productivity Factor for Interstate Exchange Access," pp. 9-10.

## F. Conclusion

Based on this review of twenty direct and indirect productivity studies, it is clear that on average, telecommunications total factor productivity grows approximately 2 percent more quickly than productivity for U.S. industry as a whole. This conclusion is confirmed over every time period tested from the recent and relatively short time period covered by the latest Christensen direct study of TFP to the longest time period considered, 1929-1993, in an indirect study. Based on these historical comparisons of TFP growth between the telecommunications industry and the U.S. as a whole, the productivity differential for a price cap formula has thus averaged about 2 percent. That is, if telephone industry prices had grown at approximately 2 percentage points more slowly than the overall rate of inflation, then telephone prices would have been growing at about the same rate as telephone costs.