

Sources:

**Telephone Total Factor Productivity**

1948-1979: L.R. Christensen, D.C. Christensen, and P.E. Schoech, "Total Factor Productivity in the Bell System, 1947-1979," Christensen Associates, Sept. 1981.

1979-1982: Bell Communications Research, "Econometric Estimation of the Marginal Operating Cost of Interstate Access," Special Report SR-FAD-000552, May 1987.

1982-1984: L.R. Christensen, "Total Factor Productivity Growth in the U.S. Telecommunications Industry and the U.S. Economy, 1951-1987," Schedule 3 to Direct Testimony, Case No. PU-2320-90-149, North Dakota Public Service Commission, 1990.

1984-1992: L.R. Christensen, P.E. Schoech, and M.E. Meitzen, "Productivity of the Local Operating Telephone Companies Subject to Price Cap Regulation, 1993 Update," Christensen Associates, January 1995.

**U.S. Economy Total Factor Productivity**

1948-1984: L.R. Christensen and D.W. Jorgenson, "U.S. Real Product and Real Factor Input, 1929-1967," Review of Income and Wealth, Series 16, March 1978, Updated September 1986.

1984-1992: U.S. Bureau of Economic Analysis, "Gross Domestic Product Price Index"; and U.S. Bureau of Labor Statistics, "Multifactor Productivity for the Private Business Sector."

**Appendix 4**

**Resume of Dr. Laurits R. Christensen**

# Laurits R. Christensen

## Resume

July 1995

Laurits R. Christensen Associates, Inc.  
University Avenue, Suite 700  
Madison, WI 53705-2164  
(608) 231-2266 FAX: (608) 231-2108

Born January 31, 1941, Manitowoc, Wisconsin 4610  
U.S. Citizen  
Social Security Number: 399-36-2345  
Married, Four Children

## Current Position

President of Laurits R. Christensen Associates, Inc., since 1976.

## Education

B.A. Economics	1964	Cornell University
M.A. Statistics	1966	University of California, Berkeley
Ph.D. Economics	1968	University of California, Berkeley
Doctoral Dissertation		Saving and the Rate of Return

## Scholarships and Fellowships

Cornell National Scholarship	1959-1964
National Defense Education Act Title IV Fellowship	1965-1967
Romnes Faculty Fellow	1979-1987

## Academic Positions

Teaching Assistant, University of California, Berkeley	1964-1965
Assistant Professor, University of Wisconsin, Madison	1967-1971
Associate Professor, University of Wisconsin, Madison	1971-1976
Professor, University of Wisconsin, Madison	1976-1987

## Other Previous Employment

Full-time consultant to U.S. Treasury, Office Of Tax Analysis, September 1971-1972.  
Full-time consultant to U.S. Bureau of Labor Statistics, Office of Prices, July 1972-December 1972.  
Visiting associate professor of economics, University of British Columbia, Spring term 1973.  
Full-time consultant to U.S. Bureau of Labor Statistics, Office of Prices, May 1973-August 1973.  
Visiting scholar, National Bureau of Economic Research, Stanford, California, Spring 1975.

## Service to the Economics Profession

Editorial consultant, American Economic Review, 1970-1972  
Member of the Board of Editors, American Economic Review, 1976-1978  
Executive Committee, Conference on Income and Wealth, National Bureau of Economic Research, 1977-1980  
Frequent referee of manuscripts for numerous journals  
Frequent reviewer of proposals for the National Science Foundation and other funding organizations

Christensen Associates

Research Funded by U.S. Government Agencies

National Science Foundation (8 multi-year grants)  
Department of Commerce  
Bureau of the Census  
Department of Energy  
Department of Labor  
Bureau of Labor Statistics  
Federal Preparedness Agency  
Postal Service

Research Funded by Other Government Agencies

Canadian Postal Service  
Canadian Transport Commission  
Illinois Commerce Commission  
Wisconsin Public Service Commission  
Wisconsin Strategic Development Commission

Publications

1. "The Measurement of U.S. Real Capital Input, 1929-1967," Review of Income and Wealth, December 1969 (with D. W. Jorgenson), pp. 293-320.
2. "U.S. Real Product and Real Factor Input, 1929-1967," Review of Income and Wealth, March, 1970 (with D. W. Jorgenson), pp. 19-50.
3. "Tax Policy and Investment Expenditures in a Model of General Equilibrium," American Economic Review, May 1970, pp. 18-22.
4. "Saving and the Rate of Return," Journal of Finance, September, 1970, abstract of doctoral dissertation, pp. 936-937.
5. "Entrepreneurial Income: How Does It Measure Up," American Economic Review, September 1971, pp. 575-585.
6. "Conjugate Duality and the Transcendental Logarithmic Production Function," Econometrica, July 1971, abstract (with D. W. Jorgenson and L. J. Lau), pp. 255-256.
7. "Measuring Economic Performance in the Private Sector," in M. Moss ed., The Measurement of Economic and Social Performance, National Bureau of Economic Research, 1973, (with D. W. Jorgenson), pp. 233-351.
8. "Simultaneous Statistical Inference in the Normal Multiple Linear Regression Model," Journal of the American Statistical Association, June 1973, pp. 457-461.
9. "Transcendental Logarithmic Production Frontiers," Review of Economics and Statistics, February 1973 (with D. W. Jorgenson and L. J. Lau), pp. 28-45.

10. "The Internal Structure of Functional Relationships: Separability Substitution, and Aggregation," Review of Economic Studies, July 1973 (with E. R. Berndt), pp. 403-410.
11. "The Translog Function and the Substitution of Equipment, Structures, and Labor in U.S. Manufacturing 1929-1968," Journal of Econometrics, March 1973 (with E. R. Berndt), pp. 81-113.
12. "U.S. Income Saving, and Wealth, 1929-69," Review of Income and Wealth, December 1973, (with D. W. Jorgenson), pp. 329-362.
13. "Testing for the Existence of a Consistent Aggregate Index of Labor Inputs," American Economic Review, June 1974 (with E. R. Berndt), pp. 391-404.
14. "Substitution Effects in Consumer Expenditures," Business Economics, January 1975, pp. 58-63.
15. "Transcendental Logarithmic Utility Functions," American Economic Review, June 1975 (with D. W. Jorgenson and L. J. Lau), pp. 367-383.
16. "Concepts and Measurement of Agricultural Productivity," American Journal of Agricultural Economics, December 1975, pp. 910-915.
17. "Cost of Living Indexes and Price Indexes for U.S. Meat and Produce, 1947-1971," in N. Terleckyj, ed., Household Production and Consumption, National Bureau of Economic Research, 1976 (with M. E. Manser), pp. 399-446.
18. "Economies of Scale in U.S. Electric Power Generation," Journal of Political Economy, August 1976 (with W. H. Greene), pp. 655-676, reprinted in Managerial Economics: Concepts, Application, and Cases, Dun-Donnelly, 1977.
19. "Estimating U.S. Consumer Preferences for Meat with a Flexible Utility Function," Journal of Econometrics, January 1977 (with M. E. Manser), pp. 37-53.
20. "An Econometric Assessment of Cost Savings from Coordination in U.S. Electric Power Generation," Land Economics, May 1978 (with W. H. Greene), pp. 139-155.
21. "Productivity Growth, 1947-1973: An International Comparison," in W. Dewald, ed., The Impact of International Trade and Investment on Employment, U.S. Department of Labor (with D. Cummings and D. W. Jorgenson), 1978.
22. "Using Statistical Cost Analysis to Estimate Marginal Costs for Electric Utilities," Proceedings of Conference on Marginal Costing and Pricing of Electrical Energy, Energy, Mines, and Resources Canada, 1978 (with W. H. Greene).
23. "Time-of-Use Pricing for Residential Electricity Customers: The Wisconsin Experiment," Proceedings of Conference on Marginal Costing and Pricing of Electrical Energy, Energy, Mines and Resources Canada, 1978 (with D. W. Caves).

24. "Modelling the Structure of Cost and Production for Multiproduct Firms," Southern Economic Journal, July 1979 (with R. S. Brown and D. W. Caves).
25. "Economic Growth, 1947-1973: An International Comparison," in J. Kendrick and B. Vaccara, editors, New Developments in Productivity Measurement and Analysis, University of Chicago Press for the National Bureau of Economic Research, 1980 (with D. Cummings and D. W. Jorgenson).
26. "Econometric Analysis of the Wisconsin Residential Time-of-Use Electricity Pricing Experiment," in the proceedings of the Workshop on Modelling of Electricity Demand by Time-of-Day, Electric Power Research Institute, December 1979, (with D.W. Caves).
27. "Comment on 'Modeling System Load Curves by Time-of-Day,'" in the proceedings of the Workshop on Modelling of Electricity Demand by Time-of-Day, Electric Power Research Institute, December 1979.
28. "Global Properties of Flexible Functional Forms," American Economic Review, June 1980 (with D. W. Caves) (abridged version of SSRI Paper #7821).
29. "Productivity in U.S. Railroads, 1951-1974," Bell Journal of Economics, Spring 1980 (with D. W. Caves and J. A. Swanson) (Data Appendix in SSRI Paper #7909).
30. "Flexible Cost Functions for Multiproduct Firms," Review of Economics and Statistics, August 1980 (with D. W. Caves and M. W. Tretheway) (abridged version of SSRI Paper #7818).
31. "The Relative Efficiency of Public and Private Firms in a Competitive Environment: The Case of Canadian Railroads," Journal of Political Economy, October 1980 (with D. W. Caves) (Data Appendix in SSRI Paper #7915).
32. "Residential Substitution of Off-Peak for Peak Electricity Usage Under Time-of-Use Pricing," The Energy Journal, 1980 (Vol. 1, No. 2) (with D. W. Caves).
33. "Comment on 'Capital and the Theory of Productivity Measurement'" (by W. E Diewert) American Economic Review: Papers and Proceedings, May 1980.
34. "Econometric Analysis of Residential Time-of-Use Electricity Pricing Experiments," (with D. W. Caves), Journal of Econometrics, Vol. 14, 287-306, 1980.
35. "U.S. Trunk Air Carriers, 1972-1977: A Multilateral Comparison of Total Factor Productivity," in Cowing and Stevenson, eds., Productivity Measurement in Regulated Industries, Academic Press, 1981 (with D. W. Caves and M. W. Tretheway).
36. "Real Product, Real Factor Input, and Productivity in the Republic of Korea, 1960-1973," (with D. Cummings), Journal of Development Economics, Vol. 18, 285-302, 1981. (Data Development in SSRI Paper #7507).
37. "The High Cost of Regulating U.S. Railroads," Regulation, January/February 1981 (with D. W. Caves and J. A. Swanson).

38. "Relative Productivity Levels, 1947-1973: An International Comparison," (with D. Cummings and D. W. Jorgenson), European Economic Review, Vol. 16, No. 1, May 1981.
39. "Productivity Growth, Scale Economies, and Capacity Utilization in U.S. Railroads, 1955-1974," (with D. W. Caves and J. A. Swanson), American Economic Review, December 1981.
40. "Economic Performance in Regulated and Unregulated Environments: A Comparison of U.S. and Canadian Railroads," (with D. W. Caves and J. A. Swanson), Quarterly Journal of Economics, November 1981.
41. "Effects on the Residential Load Curve from Time-of-Use Pricing of Electricity: Econometric Inferences from the Wisconsin Experiment for Summer System Peak Days," (with D. W. Caves), Papers and Proceedings, Electric Rate Demonstration Conference, U.S. Department of Energy, Division of Regulatory Assistance, 1982.
42. "Estimating Elasticities of Substitution in a Model of Partial Static Equilibrium: An Application to U.S. Agriculture, 1947-1974," (with R. S. Brown), Measuring and Modelling Natural Resources Substitution, E. R. Berndt and B. C. Field, editors, MIT Press, 1982.
43. "Multilateral Comparisons of Output, Input, and Productivity Using Superlative Index Numbers," (with D. W. Caves and W. E. Diewert), Economic Journal, Vol. 92, March 1982, pp. 73-86.
44. "The Economic Theory of Index Numbers and the Measurement of Input, Output, and Productivity," Econometrica, Vol. 50, No. 6, (with D. W. Caves and W. E. Diewert), November 1982.
45. "Economic Performance of U.S. and Canadian Railroads: The Significance of Ownership and the Regulatory Environment," (with D. W. Caves, J. A. Swanson, and M. W. Tretheway), in Managing Public Enterprises, W.T. Stanbury and F. Thompson, eds., Praeger, 1982.
46. "Airline Productivity Under Deregulation," Regulation, (with D. W. Caves and M. W. Tretheway), November/December 1982.
47. "Cost-Benefit Analysis of Residential Time-of-Use Rates: A Case Study for Four Illinois Utilities," (with D. W. Caves, W. E. Hendricks, and P. E. Schoech), Electric Ratemaking, December, 1982.
48. "Econometric Estimation of Scale Economies in Telecommunications," (with D. Cummings and P. E. Schoech), in L. Courville, A. R. Dobell, and A. de Fontenay, eds., Economic Analysis of Telecommunications: Theory and Applications, Vol. I, North-Holland Publishing Co., 1983.
49. "Time-of-Use Pricing for Residential Electricity Customers: Results from the Wisconsin Experiment," Public Utilities Fortnightly, (with D. W. Caves and J. A. Herriges), March 17, 1983.

50. "Productivity Performance of U.S. Trunk and Local Service Airlines in the Era of Deregulation," (with D. W. Caves and M. W. Tretheway), in Economic Inquiry, Vol. XXI, No. 3, July 1983.
51. "Comments on, 'The Bias in Price Elasticity Estimates under Homothetic Separability: Implications for Analysis of Peak Load Electricity Pricing' by D.F. Kohler," Journal of Business and Economic Statistics, (with D. W. Caves), Vol. 1, No. 3, July 1983.
52. "Transferability of Residential Response to Time-of-Use Electricity Rates," (with D. W. Caves, A. Faruqui, and J. A. Herriges), in Adjusting to Regulatory, Pricing, and Marketing Realities, MSU Public Utility Papers, 1983.
53. "Predicting Customer Response to Time-of-Use Electricity Rates: Insights from EPRI Research," (with D. W. Caves, A. Faruqui, J. A. Herriges, K. K. Lee, and A. K. Miedema), in R. F. Hill, ed., A Decade of Progress, June, 1983.
54. "Comments on 'The Diffusion of Economic Growth in the World Economy, 1950-80,'" in J.W. Kendrick, ed., International Comparisons of Productivity, Ballinger Publishing Co., 1984.
55. "Economies of Density versus Economies of Scale: Why Trunk and Local Service Airline Costs Differ," (with D.W. Caves and M.W. Tretheway), Rand Journal of Economics, Vol. 15, No. 4, Winter 1984.
56. "Consistency of Residential Customer Response in Time-of-Use Electricity Pricing Experiments," (with D. W. Caves and J. A. Herriges), Journal of Econometrics, Vol. 26, 1984, pp. 179-203.
57. "Cost-Benefit Analysis: A Comparison of Different Approaches In a Case Study of Residential Time-of-Use Electricity Pricing," (with D. W. Caves, W. Hendricks, and P. E. Schoech), Journal of Econometrics, Vol. 26, 1984, pp. 17-34.
58. "Modelling Alternative Residential Peak-Load Electricity Rate Structures," (with D. W. Caves and J. A. Herriges), Journal of Econometrics, Vol. 24, 1984, pp. 249-268.
59. "Costs and Benefits of Residential TOU Pricing in Illinois," (with D.W. Caves, W. Hendricks, and P.E. Schoech) in C.W. Ballard and P.J. Womeldorff, eds., Trends in Electric Utility Research, Pergamon Press, 1984.
60. "The Effects of New Entry on Productivity Growth in the U.S. Airline Industry," (with D.W. Caves, M.W. Tretheway, and R.J. Windle), The Logistics and Transportation Review, Vol. 21, No. 4, December 1985, pp. 299-335.
61. "Network Effects and the Measurement of Returns to Scale and Density for U.S. Railroads," (with D.W. Caves, M.W. Tretheway, and R.J. Windle) in A.F. Daugherty, ed., Analytical Studies in Transport Economics, Cambridge University Press, 1985.

62. "An Assessment of the Efficiency Effects of U.S. Airline Deregulation Via an International Comparison," (with D.W. Caves, M.W. Trethewey, and R.J. Windle) in E.E. Bailey, ed. Public Regulation: New Perspectives on Institutions and Policies, MIT Press, 1987.
63. "The Neoclassical Model of Consumer Demand with Identically Priced Commodities: And An Application to Time-of-Use Electricity Pricing," The Rand Journal of Economics, (with D. W. Caves and J. A. Herriges). Vol. 18, No. 4, Winter 1987, pp. 564-580.
64. "A Reexamination of the Cost Structure for Specialized Motor Carriers," (with J. H. Houston) The Logistics and Transportation Review, Vol. 23, No. 4, December 1987, pp. 339-351.
65. "The Importance of Economies of Scale, Capacity Utilization, and Density in Explaining Interindustry Differences in Productivity Growth," (with D. W. Caves) The Logistics and Transportation Review, Vol 24, No. 1, March 1988, pp. 3-32.
66. "Capital in the U.S. Postal Service, (with D.C. Christensen, C.G. Degen, and P.E. Schoech) in D.W. Jorgenson and R. Landau, eds. Technology and Capital Formation, 1989.

Other Papers

1. "Intertemporal Optimization and the Explanation of Consumer Behavior," (with D. W. Jorgenson), December 1968.
2. "The Geometry of Linear Hypothesis Testing in the Normal Multiple Linear Regression Model," October 1970, SSRI Paper #7037.
3. "A New Look at Farm Income in the United States," June 1971, SSRI Paper #7112.
4. "The Specification of Technology in U.S. Manufacturing," (with E. R. Berndt) March 1974, SSRI Paper #7321.
5. "Real Product, Real Factor Input, and Productivity in France, 1951-1973, (with D. W. Brazell and D. Cummings), October 1975, SSRI paper #7527.
6. "Real Product, Real Factor Input, and Productivity in Italy, 1952-1973," (with D. Cummings and B. Norton), October 1975, SSRI Paper #7528.
7. "Real Product, Real Factor Input, and Productivity in the Netherlands, 1951-1973," (with D. Cummings and P. Schoech), October 1975, SSRI Paper #7529.
8. "Real Product, Real Factor Input, and Productivity in the United Kingdom, 1955-1973," (with D. Cummings and K. Singleton), October 1975, SSRI #7530.
9. "Real Product, Real Factor Input, and Productivity in Canada, 1947-1973," (with D. Cummings), April 1976, SSRI Paper #7604.

10. "Productivity in Canadian Railroads, 1956-1975," (with D. W. Caves), October 1978, SSRI Paper #7825.
11. "Productivity in the Bell System, 1947-1977," presented at the Eighth Annual Telecommunications Policy Research Conference, Annapolis, Maryland, April 27-30, 1980 (with D. Cummings and P. E. Schoech).

Papers Presented at Professional Meetings

- 1968 Econometric Society: "Intertemporal Optimization and the Explanation of Consumer Behavior."
- 1969 American Economic Association: "Tax Policy and Investment Expenditures in a Model of General Equilibrium."
- 1970 World Congress of the Econometric Society, Cambridge, England: "Entrepreneurial Income: How Does It Measure Up?" and "Conjugate Duality and the Transcendental Logarithmic Production Function."
- 1971 Twelfth General Conference of the International Association for Research in Income and Wealth: "A New Look at Farm Income in the United States."
- 1971 Winter Meetings of the Econometric Society: "The Translog Production Function and Factor Substitution in U.S. Manufacturing, 1929-1968."
- 1972 Western Economic Association Meeting: "Testing for the Existence of a Consistent Aggregate Index of Labor Inputs."
- 1972 Conference on Applications of Duality Theory, Canadian Department of Manpower and Immigration: "The Internal Structure of Functional Relationships: Separability, Substitution, and Aggregation" and "Testing for the Existence of a Consistent Aggregate Index of Labor Inputs."
- 1972 Winter Meetings of the Econometric Society: "The Translog Utility Function and the Substitution of Meats in U.S. Consumption, 1946-1968."
- 1973 Western Economic Association Meetings: "The Specifications of Technology in U.S. Manufacturing."
- 1973 Conference on Household Production and Consumption, National Bureau of Economic Research: "Cost of Living Indexes and Price Indexes for U.S. Meat and Produce, 1947-1972."
- 1974 Annual Meetings of the National Association of Business Economists: "Substitution Effects in Consumer Expenditures."

- 1975 Annual Meetings of the American Agricultural Economics Association: "Concepts and Measurement of Agricultural Productivity."
- 1975 Third World Congress of the Econometric Society: "A New Look at Returns to Scale in Electricity Supply."
- 1975 Conference on New Developments in Productivity Research, National Bureau of Economic Research: "An International Comparison of Growth in Productivity, 1947-1973."
- 1976 Econometric Society Meetings, Atlantic City, New Jersey: "An Econometric Assessment of Cost Savings from Coordination in U.S. Electric Power Generation" and "Modelling the Structure of Production in the U.S. Railroad Industry."
- 1976 Conference on the Impact of International Trade and Investment on Employment, Washington, D.C.: "Productivity Growth, 1947-1973: An International Comparison."
- 1977 Econometric Society Meetings, New York, N.Y.: "Consumer Demand for Automobiles in the U.S."
- 1978 Canadian Electrical Association and Energy, Mines, and Resources Canada, Conference on Marginal Costing and Pricing of Electrical Energy: (1) "Time-of-Use Pricing for Residential Electricity Customers: The Wisconsin Experiment"; (2) "Using Statistical Cost Analysis to Estimate Marginal Costs for Electric Utilities."
- 1978 Electric Power Research Institute, Workshop on Energy Utilization and Conservation: "Econometric Analysis of the Wisconsin Residential Time-of-Use Pricing Experiment."
- 1978 American Economic Association, "Economic Performance in Regulated and Unregulated Environments: The Case of U.S. and Canadian Railroads."
- 1979 NSF Conference on Productivity in Regulated Industries: "Total Factor Productivity of U.S. Trunk Air Carriers, 1971-1977."
- 1979 Wisconsin Public Service Commission Conference on Time-of-Use Pricing: "Effects on the Residential Load Curve from Time-of-Day Pricing of Electricity: Econometric Inferences from the Wisconsin Experiment."
- 1979 AEA Annual Meetings: Comment on "Capital and Theory of Productivity Measurement" (by W. E. Diewert).
- 1980 U.S. Department of Energy Electric Utility Rate Conference: "Effects on the Residential Load Curve from Time-of-Use Pricing of Electricity: Econometric Inferences from the Wisconsin Experiment for Summer System Peak Days."
- 1980 International Seminar on Macroeconomics: "Relative Productivity Levels, 1947-1973: An International Comparison."

- 1980 Eight Annual Telecommunications Policy Research Conference: "Productivity in the Bell System, 1947-1977."
- 1980 American Economic Association: "Relative Productivity Levels, 1947-1973: An International Comparison."
- 1980 Econometric Society: (1) "Econometric Estimation of Scale Economies in Telecommunications," (2) "Economies of Scale for U.S. Trunk Air Carriers, 1972-1978."
- 1981 Telecommunications in Canada, Economic Analysis of the Industry (Montreal, Quebec): "Econometric Estimation of Scale Economies in Telecommunications."
- 1981 International Association of Energy Economists (Toronto, Canada): "Econometric Results from the Wisconsin Time-of-Day Rate Demonstration Project."
- 1981 Institute for Research on Public Policy and UCLA: Managing Public Enterprises; Purposes and Performance (Vancouver, British Columbia): "The Significance of Ownership and the Regulatory Environment: Economic Performance of U.S. and Canadian Railroads."
- 1982 Conference on International Comparisons of Productivity, sponsored by the American Enterprise Institute (Washington, D.C.) "Comments on 'The Diffusion of Economic Growth in the World Economy, 1950-80.'"
- 1982 Fourteenth Annual Conference of the Institute for Public Utilities: "Transferability of Residential Response to Time-of-Use Electricity Rates."
- 1982 Econometric Society: "Economies of Density and the Effects of Network: A Re-evaluation of Scale Economies for U.S. Trunk Airlines."
- 1983 Western Economic Association: "The Success of the Residential Time-of-Use Electricity Pricing Experiments."
- 1983 Econometric Society: "Cost-Benefit Analysis: A Comparison of Different Approaches In a Case Study of Residential Time-of-Use Electricity Pricing."
- 1983 Econometric Society: "Estimating the Cost Savings from Rail Mergers."
- 1984 Conference on Interindustry Differences in Productivity Growth sponsored by the American Enterprise Institute (Washington, D.C.): "The Importance of Economies of Scale, Capacity Utilization, and Density in Explaining Interindustry Differences in Productivity Growth."
- 1985 National Bureau of Economic Research, U.S.-Japan Productivity Conference (Cambridge, Mass.): Discussant for "Bilateral Models of Production for Japanese and U.S. Industries."
- 1985 National Science Foundation/Carnegie Mellon University Conference on Regulation (Airlie, Virginia): "An Assessment of the Efficiency Effects of U.S. Airline Deregulation Via an International Comparison."

**REPLY TESTIMONY**  
**OF**  
**DR. LAURITS R. CHRISTENSEN**

**BEFORE THE**  
**PUBLIC UTILITIES COMMISSION**  
**OF THE STATE OF CALIFORNIA**

**ON BEHALF OF**  
**PACIFIC BELL**

**INVESTIGATION NO. 95-05-047**

**September 18, 1995**

**REPLY TESTIMONY OF DR. LAURITS R. CHRISTENSEN**

**Q. Please state your name.**

**A. My name is Laurits R. Christensen.**

**Q. Have you previously filed testimony in this proceeding?**

**A. Yes, I have filed prepared direct testimony along with the report, "Telephone Industry Productivity Performance and its Implications for the Pacific Bell Price Cap Formula."**

**Q. What is the purpose of your reply testimony?**

**A. The purpose of my reply testimony is primarily to respond to the testimony of Dr. Lee L. Selwyn concerning my 1984-1993 LEC TFP study, its support of the conclusion that the TFP growth differential between the telephone industry and the U.S. economy has remained stable at about 2 percent, and the conclusion that this is the most appropriate estimate of the prospective TFP growth differential. I also explain why Dr. Selwyn's proposal for a prospective input price differential of 2.6 percent is not supported by the data and is totally without merit. The DRA witnesses also make some of the same**

points and I reply to them as well. My reply is presented in the report entitled, "Further Review of the Productivity Factor and the Price Cap Formula," dated September 18, 1995. A copy of the report is attached.

**Q. Does this complete your prepared reply testimony?**

**A. Yes, it does.**

**FURTHER REVIEW OF THE PRODUCTIVITY FACTOR  
AND THE PRICE CAP FORMULA**

**Prepared for  
Pacific Bell**

**By**

**Laurits R. Christensen  
Christensen Associates, Inc.  
4610 University Avenue  
Madison, Wisconsin 53705**

**September 18, 1995**

# **FURTHER REVIEW OF THE PRODUCTIVITY FACTOR AND THE PRICE CAP FORMULA**

## **Table of Contents**

<b><u>Section</u></b>	<b><u>Page</u></b>
<b>1. Purpose of Report</b>	<b>1</b>
<b>2. The Long-Term TFP Growth Differential is About 2 Percent, it Has Remained Stable Over Time and Represents the Most Appropriate Basis for Setting X in a Price Cap Formula</b>	<b>3</b>
<b>3. The Expected Input Price Differential is Zero Despite Short-Term Deviations Around This Trend, Leading to the Conclusion that There Should be no Input Price Term Included in the X Factor</b>	<b>8</b>
<b>4. Conclusion: The Most Appropriate Basis for Determining the X Factor is the Long-Term TFP Growth Differential with no Adjustments for Input Prices</b>	<b>13</b>

## **1. Purpose of Report**

In my September 8, 1995 report filed in this proceeding, I concurred with Pacific Bell that if a price cap formula with a productivity offset is to be continued, the offset should be no more than 2 percent because this is the long-term TFP growth differential between the national telephone industry and the overall U.S. economy.

In this report, I primarily reply to the testimony of Dr. Lee L. Selwyn. I cover three significant areas.

1. A review of telephone industry TFP studies shows that the TFP growth differential between the telephone industry and the U.S. economy is approximately 2 percent, and this differential has remained stable over time. My updated LEC TFP study reports a differential of 2.1 percent over the 1984-1993 period and is consistent with the results of the other studies. Contrary to Dr. Selwyn's assertions, the TFP growth differential has shown no signs of widening. Despite criticisms by Dr. Selwyn, the data corrections between my original and updated LEC TFP studies have been thoroughly documented and their impact on the results of my study are minimal.
2. The long-term input price growth differential between the national telephone industry and the U.S. economy is zero, although there has been short-term volatility in this differential. This conclusion is reaffirmed in the research presented by GTE California, Incorporated (GTEC) witness Dr. Gregory M. Duncan in this proceeding. Because of the volatility of the series and its long-run trend value of zero, there is

no basis for using the short-term input price differential from the 1984-1992 period to project a forward-looking input price differential as Dr. Selwyn has done.

3. Therefore, going forward, if the GDPPI - X price cap formula is retained for Pacific Bell, the most appropriate X factor is the long-term TFP growth differential. It has remained stable despite dramatic changes in industry technology over time. The TFP growth differential's expected future value is best represented by its long-term value of about 2 percent. In contrast, the input price growth differential is subject to large swings, so that lower telephone input prices in one short-run period have been followed by higher telephone input prices in subsequent periods. The long-term input price differential of zero is the best estimate of its value going forward and, therefore, an input price adjustment should not be included in the X factor.

**2. The Long-Term TFP Growth Differential is About 2 Percent, it Has Remained Stable Over Time and Represents the Most Appropriate Basis for Setting X in a Price Cap Formula**

Review of Telephone Industry TFP Studies. In my September 8 report, I surveyed the results of telephone industry TFP studies, including my study of the post-divestiture LEC industry. That review indicated that the difference between telephone industry TFP growth and U.S. economy TFP growth ranged between 1.85 percent and 2.2 percent.<sup>1</sup> The 2.1 percent TFP growth differential from my updated LEC TFP study falls within this range. I concluded that the long-term TFP growth differential has remained stable in the 2 percent range over time and, in fact, has not widened with divestiture.<sup>2</sup> On this basis, I concluded that the stable long-term TFP growth differential of 2 percent was the best estimate of the expected differential going forward, and is an appropriate basis for the price cap X factor. There is no indication of deviation from this trend or that the trend is changing.

Chart 1 presents the long-term annual average rates of TFP growth for the telephone industry and the U.S. economy.<sup>3</sup> Average annual TFP growth over the 1948-1993 period has been 2.86 percent for the telephone industry and 0.91 percent for U.S. economy, for an average differential of 1.94 percent.

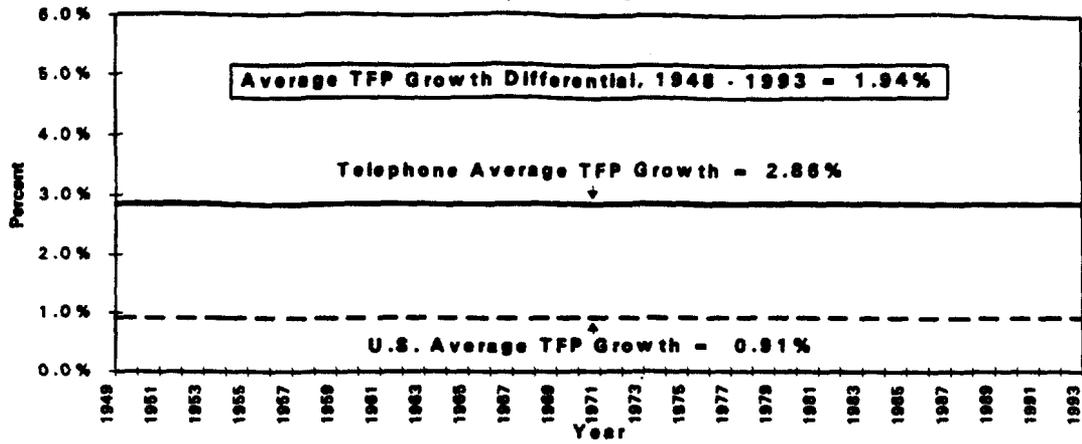
---

<sup>1</sup> Prepared Testimony of Laurits R. Christensen, Investigation No. 95-05-047, September 8, 1995, p. 11.

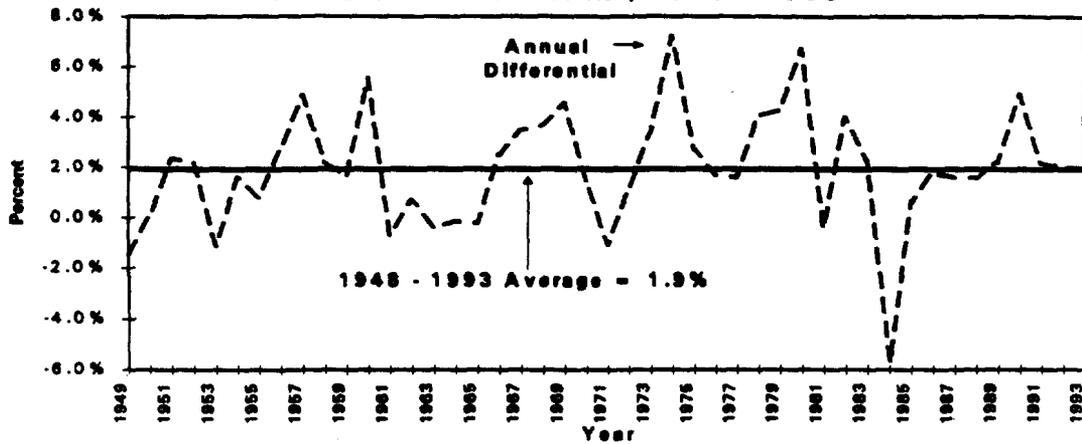
<sup>2</sup> Christensen, p. 15.

<sup>3</sup> The growth rates in the charts and tables are year-over-year growth rates and, therefore, the first data point is in the second year of the series. For example, growth rates for series beginning in 1948 are shown as values in 1949 (the 1949 over 1948 growth rate), and growth rates for series beginning in 1984 are shown as values in 1985 (the 1985 over 1984 growth rate). Also note that all growth rates are computed using logarithms.

**Chart 1**  
**Average Telephone Industry and U.S. Economy TFP Growth, 1948 - 1993**



**Chart 2**  
**TFP Growth Differential, 1948 - 1993**



**Chart 3**  
**TFP Growth Differential, 1984 - 1993**

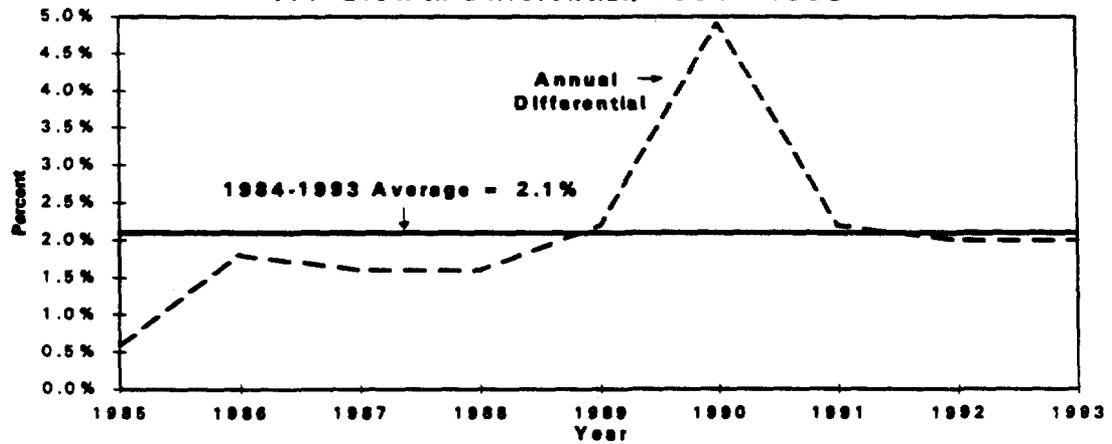


Chart 2 presents the long-term differential of 1.94 percent and the annual growth differentials over the 1948-1993 period. Chart 3 presents the 1984-1993 average differential for the period of 2.1 percent and the annual differentials from my LEC TFP study. It can be seen that the results of my recent study conform with the long-term average.

Dr. Selwyn has claimed that future productivity growth will likely be considerably greater than it has been in the past.<sup>4</sup> However, he provides no credible empirical support. His reference to the "exploding pace of technological change" is a legacy of the telecommunications industry. The industry has always been at the forefront of technological innovation and this has been manifested in a higher rate of TFP growth for the telephone industry relative to the rest of the economy. There is no evidence that recent and prospective developments have resulted or will result in a widening of the TFP growth differential. Dr. Selwyn also claims that telephone company input price growth rates will remain well below the overall economy-wide inflation rate, leading to higher productivity growth. However, as I demonstrate in the next section, this claim is without merit. Dr. Selwyn also claims that increasing competition will lead to higher productivity growth for the local exchange carriers. However, as I demonstrated in my September 8 report, increased competition for "high margin" services, such as toll, can lead to declines in TFP growth if the output growth of these services declines.

---

<sup>4</sup> Testimony of Lee L. Selwyn, Investigation No. 95-05-047, September 8, 1995, p. 27.

In summary, despite his claim that telephone industry TFP growth will be increasing in the future, Dr. Selwyn has not provided any evidence to indicate an impending change in the TFP growth differential between the telephone industry and the U.S. economy.

Data Corrections to My LEC Study. Dr. Selwyn claims (pp. 48-49) that my updated LEC TFP study is a *totally revised* study that "appears to constitute a major revision of the earlier work, including pervasive and significant modifications to the underlying historical data for the same 1984-1992 period included in the original study." He also alleges that the "'corrections' and 'updates' filed with the FCC in January have never been adequately explained or justified."<sup>5</sup>

The facts are entirely different from the claims of Dr. Selwyn: the corrections represented minor changes in data that were completely documented and had a minimal impact on the results of the study. Furthermore, as I explain in the following section, Dr. Selwyn's claim that I incorporated other supposedly unreported revisions that narrowed the input price differential but left the TFP results essentially unchanged, is based on faulty reasoning.

Table 1 compares the 1984-1992 average annual growth rates of my original LEC TFP study and the updated study that incorporated the data corrections.<sup>6</sup>

---

<sup>5</sup> Selwyn, pp. 48-49.

<sup>6</sup> The 1984-1992 period is used because it represents the common period covered by my two LEC studies.

**Table 1**  
**Comparison of Results for Original and**  
**Updated Christensen LEC TFP Studies**  
**1984-1992**

	<u>Original Study</u>	<u>Updated Study</u>
Output Quantity	3.5%	3.4%
Input Quantity	0.9%	1.0%
TFP	2.6%	2.4%
U.S. TFP	0.3%	0.3%
TFP Differential	2.3%	2.1%
Input Price	1.1%	1.7%
U.S. Input Price	4.0%	4.0%
Input Price Differential	-2.9%	-2.2%

It can be seen that the average annual LEC TFP growth changed from 2.6% to 2.4% and the differential changed from 2.3% to 2.1%, a very minimal change. Input price growth changed from 1.1% to 1.7% and the differential changed from -2.9% to -2.2%. Given the volatility of the input price series (e.g., annual values of the input price growth differential ranged from +7.7 percent to -7.8 percent over the 1984-1992 period), this represents an insignificant change.

In summary, it is standard procedure to update economic studies as better data become available. Most data series published by the U.S. government are revised on a regular basis and researchers routinely use the revised data. Given the minimal impact on the results and the faulty basis for his assertions, Dr. Selwyn's claims of data manipulation in my LEC TFP study are totally unfounded.

**3. The Expected Input Price Differential is Zero Despite Short-Term Deviations Around This Trend. Leading to the Conclusion that There Should be no Input Price Term Included in the X Factor**

In my September 8 report, I provided the general results on my 1948-1992 input price research that concluded that, over the 1948 to 1992 period, input prices for the U.S. economy and the telephone industry grew at almost the same rate. Over this period, input prices grew at an average annual rate of 4.8 percent for the U.S. economy and 4.7 percent for telephone companies. Statistical tests find there is no evidence that the input price trends differ for the telephone industry and the U.S. economy for the full 1948-1992 period. It is extremely important to note that the same conclusion holds for the 1948-1984 and 1984-1992 subperiods.

This means that any observed short-term differences in input price growth do not represent a difference in the underlying trends of input prices. The volatility of this series is so great that observed differences cannot be statistically distinguished from a difference of zero. This also means there is no statistical basis for using an observed short-run differential as a projection of expected future trends. These conclusions are supported by the research of GTEC witness Dr. Gregory M. Duncan in this proceeding.<sup>7</sup> Therefore, the attempt by Dr. Selwyn to use the 1984-1992 input price growth differential as a projection of expected input price performance is without statistical foundation and has no merit.

The events producing the observed 1984-1992 input price differential are not likely to repeat themselves going forward. From 1984 to 1993 the

---

<sup>7</sup>Testimony of Dr. Gregory M. Duncan, Investigation No. 95-05-047, September 8, 1995.